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FOURTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1902.

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HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

OFFICERS.

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GEORGE A. DREW, B.Sc.,	*Assistant Horticulturist.*
——— ———	*Assistant Horticulturist.*
HENRY L. BODFISH,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand : —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 57. Fertilizer analyses.
No. 59. Fertilizer analyses.
No. 63. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.
No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 69. Rotting of greenhouse lettuce.
No. 70. Fertilizer analyses.
No. 71. Concentrated feed stuffs; condimental stock and poultry foods.
No. 72. Summer forage crops.
No. 73. Orchard experiments; fertilizers for fruits; thinning fruits; spraying fruits.
No. 75. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 77. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

An outline of the more important work undertaken and the results secured is all the limits of our space will allow. From a series of experiments on the effect of feed on the compounds of milk and on the consistency of butter, particularly the effect of cotton-seed meal with a minimun amount of oil and likewise with the addition of cotton-seed oil on the relative properties of the several ingredients in milk and butter fat and on the body of the butter, the results seemed to be as follows : —

1. Cotton-seed meal with a minimum percentage of oil did not alter the percentage composition of the milk.

2. The addition of one-half to three-fourths of a pound of cotton-seed oil to the cotton-seed meal appeared to increase the fat percentage in the milk about .4 of 1 per cent. (5 to 5.4), and this increase was maintained during the six weeks of the feeding period.

3. The substitution of Cleveland flax meal for the cotton-seed meal and oil resulted in a decrease of the butter fat to about the percentage found in the first period, while the nitrogen percentage was increased. This change in composition was probably due to the removal of the cotton-seed oil from the ration, and not to the influence of the flax meal.

4. Cotton-seed meal with minimum oil caused no marked variation in the chemical composition of the butter fat.

5. The addition of cotton-seed oil to the cotton-seed meal ration produced a noticeable increase in the melting point and iodine number of butter fat.

6. Cotton-seed meal with a minimum oil produced a firm butter.

7. The addition of cotton-seed oil, while it increased the melting point of the butter fat, produced a softer, more yielding butter than that produced by either the cotton-seed meal or the standard ration.

8. An excess of cotton-seed oil in the ration is likely to affect the health of the animal.

Close attention was paid to the composition of concentrated feeds, and the farmers were warned of the following adulterations : cotton-seed meal mixed with fine ground hulls for genuine meal ; finely ground corn-cobs for middlings in mixed feeds ; finely ground rice hulls in the adulteration of standard grains ; and oat offal instead of ground oats in mixing the so-called provender or cracked corn and ground oats.

In experiments with green crops, wheat and winter vetch were found preferable to winter rye for early forage ; the chief value of barnyard millet was found to lie in its use as green fodder, by successive seedings using it until September. It was found to be not suitable for hay and taking the

place of corn for silage when impossible to secure a crop of corn. Experiments were also made in growing mixtures of legumes and non-legumes, in order to increase the amount of protein in the several forage crops, in the hope that the farmer would not require to purchase so much grain. Longfellow corn and black cow peas were sown, yielding at the rate of 23 tons to the acre.

The entomological division has been chiefly occupied with the elm-leaf beetle; the brown-tail moth, which now covers an area of twelve hundred square miles, extending into Maine and New Hampshire; the gypsy moth, which, since the abandonment of the crusade against it, is now reappearing in the places from which it was surely being driven out; and the San José scale, which is now found in fifty-two localities in Massachusetts, and is attacking not only nurseries but all deciduous trees and shrubs. In one place, covering an area of five square miles, nearly every tree and shrub are affected. It would seem as if these four pests had come to stay, and three of them are spreading over the State with great rapidity. How to preserve our noble trees and fruitful orchards is the question that comes to all of us.

The botanical division has pursued its investigations in the sterilization of soil, examining into the various methods in use and the cost of the same. Desiccation or drying of the soil was found to increase the activity of the drop fungus, and on lettuce resulted in a stunted growth and an abnormally colored and worthless crop. The chrysanthemum rust, though very widely spread, is not considered of serious consequence, because it passes through only one stage, the uredo, and hence does not gain a strong foothold. The remedy seems to lie in selection of rust-free stock and inside cultivation, the latter being due to avoidance of mist and dew on the foliage, and therefore furnishing a less favorable opportunity for the spores to germinate and cause injury.

Three melon diseases have been recognized and studied, one a leaf blight, and two affecting both leaves and fruit. They have been particularly severe the past year, complaints coming from every part of the State. In general, the remedies seem to lie in maturing the crop as early as possible

by selecting early varieties or by transplanting, and spraying with Bordeaux mixture. The last mentioned is open to objection, from the difficulty of spraying both sides of the leaf.

Various stem rots, affecting the chrysanthemum, carnation and aster, have been the subject of careful investigation. These rots are produced by fungous growths clogging up the pores of the stem, and resulting in decay. In the aster the disease can be entirely averted by starting plants in the open ground, or otherwise avoiding "damping-off" conditions. In the chrysanthemum and carnation reliance is placed upon the use of hardy propagating stock and sterilized soil.

In the agricultural division the problems have been chiefly those connected with the nutrition of plants and the selection and use of fertilizers and manures. The results of the year's work seem to show (*a*) that sulfate of potash is superior to the muriate for clovers, while for cabbages the muriate is slightly superior; (*b*) that, used in connection with manures for garden crops, the sulfate of potash is better for early crops, while for late crops the muriate is of equal value; (*c*) that, in determining the relative value of phosphates applied on the basis of equal quantities of actual phosphoric acid, their relative standing was in the following order: raw bone, phosphatic slag, South Carolina rock, apatite, dissolved bone meal, dissolved bone-black, Tennessee phosphate, acid phosphate, steamed bone meal, Florida phosphate; (*d*) that, in a comparison of different varieties of ensilage corn, in the total yield they stood in the following order: Eureka, Boston Market, Rural Thoroughbred, Leaming Field, but in actual food value the Leaming Field, when ensiled, was superior; (*e*) that, in soil tests with grass, grass showed a marked dependence upon a liberal supply of fertilizer nitrogen and clover a still closer dependence upon a liberal supply of fertilizer potash; (*f*) that, in soil tests with onions, that crop showed a close dependence upon a liberal supply of potash, an abundant supply of lime for promoting the healthy growth of the crop and a liberal supply of readily available phosphate for

promoting the satisfactory ripening of the crop; (*g*) that, on a moderately sloping field, it was found better to haul manure in the late autumn to large piles and spread and plough in the spring than to haul in the autumn and apply directly to the field, as the crops were increased more than enough to cover the extra cost of rehandling the manure. Growing alfalfa for a forage crop has proved quite unsuccessful, after a number of years' trial, the crop being exceedingly small. Mand's Wonder Foreign Crop, Brazilian millet and Pearl millet prove identical in every respect, and farmers are warned not to pay, under a new name, the high prices demanded for the old and well-known Pearl millet.

The details of the experiments thus briefly outlined may be found in the reports of the several divisions herewith submitted.

ANNUAL REPORT

OF GEORGE F. MILLS, *Treasurer* OF THE HATCH EXPERIMENT STATION OF MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1901.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$8,157 57	
for labor,	2,941 04	
for publications,	1,436 30	
for postage and stationery,	269 33	
for freight and express,	99 82	
for heat, light, water and power,	259 63	
for seeds, plants and sundry supplies,	621 30	
for fertilizers,	182 21	
for feed stuffs,	135 08	
for library,	221 31	
for tools, implements and machinery,	52 58	
for furniture and fixtures,	75 59	
for scientific apparatus,	5 49	
for live stock,	20 25	
for travelling expenses,	84 39	
for contingent expenses,	147 52	
for building and repairs,	290 59	
		$15,000 00
Cash received from State treasurer,	$11,200 00	
from fertilizer fees,	3,490 25	
from farm products,	2,091 08	
from miscellaneous sources,	2,050 50	
		$18,831 83
Cash paid for salaries,	$11,099 76	
for labor,	1,620 38	
for publications,	681 28	
for postage and stationery,	318 65	
for freight and express,	102 49	
for heat, light, water and power,	434 12	
Amount carried forward,	$14,256 68	

Amount brought forward,		$14,256 68	
Cash paid	for chemical supplies,	534 45	
	for seeds, plants and sundry supplies,	428 27	
	for fertilizers,	510 88	
	for feed stuffs,	691 99	
	for library,	130 38	
	for tools, implements and machinery,	122 28	
	for furniture and fixtures,	22 25	
	for scientific apparatus,	435 41	
	for live stock,	318 00	
	for travelling expenses,	663 12	
	for building and repairs,	718 12	
			$18,831 83

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1901; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $33,831.83 and the corresponding disbursements, $33,831.83. All the proper vouchers are on file. These have been examined by me and have been found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1901.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 1, 1901.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

The work of the agricultural division of the experiment station for the past year has followed the general lines of investigation already undertaken. The problems chiefly engaging attention are those connected with the nutrition of plants and the selection and use of manures and fertilizers. These problems are of fundamental importance in the agriculture of the State; and, as our lines of inquiry are followed up from year to year, it is believed that little by little the results must contribute to the sum of our knowledge pertaining to many vital points.

It may possibly have been thought by some that, as comparatively few of our farmers yet use unmixed fertilizers, it can scarcely benefit them greatly to know the relative values of many of the materials dealt with in our experiments. This view is superficial, for, even though farmers may not yet largely employ chemicals, the manufacturers of mixed materials, always on the lookout for new light as to the needs of the various crops, are gradually modifying their goods in accordance with *well-established results of experiments*.

To cite one or two examples: one of the best-known brands of potato fertilizers, as made twelve years ago, had the following percentage composition: nitrogen, 4.12; soluble and available phosphoric acid, 7.59; total phosphoric acid, 12.17; potash, 5.23. As made last year, the same brand of fertilizer contained: nitrogen, 2.92; soluble and available phosphoric acid, 6.45; total phosphoric acid, 8.27; potash, 10. Twelve years ago most potato fertilizers contained potash in the form of muriate; they now very

generally contain this element in the form of sulfate. Such changes are in the interest of the farmers who use these fertilizers; and they are in line with suggestions based upon experiments here as well as in other stations.

The experiments with fertilizers are conducted in three distinct methods, — the plot method in the open field, the plunged cylinder method with equal weights of thoroughly mixed soil to the depth of four feet, and the pot method. The last two are valuable as checks on the results in the field, and in increasing the possible range and scope of inquiry. In our work in the field we have employed two hundred and twenty-two plots, we have one hundred and fifty-three of the cylinders in use, while in our pot experiments we have cared for two hundred and ninety-four pots.

The results of cylinder and pot experiments, being rather of scientific than of immediate practical interest, will not be presented in this report. Variety tests with corn and potatoes have engaged a considerable share of attention, but the varieties under trial have been tested but a single year, and results will not be reported. Our experiments with poultry have been directed, as in recent years, to a study of the best methods of feeding for eggs. The results, not being regarded as decisive and in some respects at variance with those of earlier years, will not be discussed in this report. This report, then, will deal only with the results of some of our more important plot experiments. The nature of the subjects of inquiry and the more salient features of our results will be made clear by the following statement: —

I. — To determine the relative value of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen. The crop of this year, soy beans, gives yields on the basis of which the materials rank in the following order: barnyard manure, nitrate of soda, dried blood, sulfate of ammonia. The average to date ranks the materials in the following order: nitrate of soda, barnyard manure, sulfate of ammonia, dried blood.

II. — To determine the relative value of muriate and high-grade sulfate of potash for field crops. Results of the year

indicate sulfate to be superior to the muriate for clovers; for cabbages, the muriate proves slightly superior.

III. — *A*. To determine the relative value of nitrate of soda, sulfate of ammonia and dried blood, used in connection with manure as sources of nitrogen for garden crops. Results indicate these materials used in amounts furnishing equal nitrogen to rank in the following order: nitrate of soda, dried blood, sulfate of ammonia. *B*. To determine the relative value of sulfate of potash and muriate of potash, used in connection with manures for garden crops. Results of the year indicate the sulfate to be the better for early crops, while for late crops the muriate is equally good.

IV. — To determine the relative value of different phosphates used in equal money's worth. The results of the year rank the materials employed in the following order: phosphatic slag, South Carolina rock, Mona guano, dissolved bone-black, Florida rock phosphate.

V. — To determine the relative value of phosphates, applied on the basis of equal quantities of actual phosphoric acid. The relative standing of the several phosphates was in the following order: raw bone, phosphatic slag, South Carolina rock, apatite, dissolved bone meal, dissolved bone-black, Tennessee phosphate, acid phosphate, steamed bone meal, Florida phosphate.

VI. — To determine the relative value of different potash salts for field crops. The results of the year with wheat and corn are not very decisive, but indicate a high rate of availability for the new materials, — silicate and carbonate of potash.

VII. — Comparison of different varieties of ensilage corn. In total yield the varieties under trial rank in the following order: Eureka, Boston Market, Rural Thoroughbred, Leaming Field. In actual food value the Leaming Field when ensiled is superior.

VIII. — *A*. Soil test with grass. Results of the year indicate the close dependence of grass upon a liberal supply of fertilizer nitrogen, and the still closer dependence of clover upon a liberal supply of fertilizer potash. They also establish the possibility of raising profitable hay crops by

the use of fertilizers only, and indicate that in grass mixtures where clover is sown exceedingly profitable crops can be grown by the combination of a potash salt and an available phosphate. *B.* Soil test with onions. Results indicate the close dependence of this crop upon a liberal supply of potash, the vital importance of an abundant store of lime for the healthy growth of the crop, and of a liberal supply of readily available phosphate for promoting satisfactory ripening of the crop.

IX. — To determine the relative value for production of corn and grass in rotation of a large application of manure alone, as compared with a smaller application of manure with a moderate amount of potash salts. The crop of this year is mixed grass and clover. The result of the experiment was the production of nearly equal total weights of hay under the two systems, and hay of superior nutritive quality, because containing a larger proportion of clover, on the combined manure and potash.

X. — To determine the relative value for crop production of two fertilizer mixtures, one furnishing the important elements of plant food in the same proportions as in "special" corn fertilizers, the other furnishing less phosphoric acid and more potash, for corn and grass in rotation. The crop of this year is grass, and the mixture containing less phosphoric acid and more potash and costing the smaller sum per acre gives a larger yield both of hay and rowen, and in both cases of superior nutritive value on account of the large proportion of clover.

XI. — To determine the economic result of using in rotation on grass lands : the first year, ashes ; the second, ground bone and muriate of potash ; and the third, barnyard manure. The yields are large, amounting under these several systems of manuring to from rather over 3¼ to nearly 3¾ tons per acre. These yields are produced on a good margin of profit.

XII. — To determine whether the use of nitrate of soda for rowen is profitable. The results on an old sod consisting chiefly of Kentucky blue-grass is an increased rowen crop, resulting from the application of nitrate of soda at a

fair profit; on a Timothy sod the results on different plots vary widely, and the average is a small increase, produced at a cost greater than its value.

XIII. — To determine which is the better practice: to haul manure and spread directly on the field during late autumn or winter, or to haul at the same time to large piles in the field, to be spread and immediately ploughed in in the spring. The results indicate that on land sloping moderately the spring application is to be preferred, as the crops are more than sufficiently large to cover the extra cost of rehandling the manure.

XIV. — To determine the value of alfalfa as a forage crop for this locality. The results of a number of years are quite discouraging, as, with the most careful attention to tillage, manuring and keeping free from weeds, the crops are exceedingly small, — hardly one-half what might confidently be expected from clover under similar conditions.

XV. — To determine whether Mand's Wonder Forage Crop and Brazilian millet are different from Pearl millet. Results indicate that these three crops are identical in every respect, and that it will not pay farmers to give the high prices demanded for the old and long-known Pearl millet under a new name.

I. — The Relative Value of Manures furnishing Nitrogen. (Field A.)

A detailed description of the plan of experiment followed in this field will be found in the twelfth annual report. The materials under comparison are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. These wherever used are applied in such quantities as to furnish equal amounts of nitrogen. There are three plots in the field to which no nitrogen in any form has been applied. All the plots in the field receive the same amounts of phosphoric acid and potash. This experiment was begun in 1890, and the crops which have been grown previous to this year, in the order of succession, are: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover and potatoes. As

a result of all experiments previous to this year, it is found that the materials furnishing nitrogen have produced crops ranking in the following order: —

	Per Cent.
Nitrate of soda,	100
Barnyard manure,	90
Sulfate of ammonia,	89
Dried blood,	86
The plots receiving no nitrogen,	68

The crop for this year was soy beans. Growth was vigorous and healthy, the crop on all plots good. The yields are shown in the following table: —

Yield of Soy Beans per Acre.

Plots.	Nitrogen Fertilizer.	Beans (Bushels).	Straw (Pounds).
Plot 0,	Barnyard manure,	32.75	2,700
Plot 1,	Nitrate of soda,	31.55	2,750
Plot 2,	Nitrate of soda,	32.75	2,500
Plot 3,	Dried blood,	28.62	2,600
Plot 4,	No nitrogen,	28.97	2,600
Plot 5,	Ammonium sulfate,	28.10	2,300
Plot 6,	Ammonium sulfate,	31.03	3,050
Plot 7,	No nitrogen,	25.86	2,350
Plot 8,	Ammonium sulfate,	28.97	2,550
Plot 9,	No nitrogen,	27.93	2,200
Plot 10,	Dried blood,	33.28	2,600

The average results are as follows: —

Fertilizer.	Beans (Bushels).	Straw (Pounds).
Average of the no-nitrogen plots (3),	27.59	2,386.7
Nitrate of soda plots (2),	32.15	2,650.0
Dried blood plots (2),	30.95	2,600.0
Sulfate of ammonia plots (3),	29.37	2,633.3

The relative standing of the different manures in the yield of grain is: —

	Per Cent.
Manure,	100.0
Nitrate of soda,	98.1
Dried blood,	94.5
Sulfate of ammonia,	89.7
No nitrogen,	84.3

In yield of straw the rank is: —

	Per Cent.
Barnyard manure,	100.0
Nitrate of soda,	98.1
Sulfate of ammonia,	97.5
Dried blood,	96.3
No nitrogen,	88.4

It will be seen that the different materials stand more nearly together this year than is the average of preceding years. The manure stands relatively higher than in former years, but the fertilizers stand in the same relative order, nitrate of soda proving the most efficient of the nitrogen fertilizers, and sulfate of ammonia the least as measured by grain production, while it is slightly ahead of the blood in the yield of straw. The comparatively even results of this year are doubtless to be accounted for chiefly by the fact that the crop of this season, the soy bean, is one capable of drawing upon the atmosphere for a considerable share of the nitrogen it requires. The development of nodules upon the roots of the crop this year was very abundant. In spite of this fact, it will be noticed that the crop on the no-nitrogen plots stands considerably below that on the other plots. It is, however, doubtless much more nearly on an equality with them than would have been the case with a crop not belonging to the clover family.

II. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

This experiment has been in progress since 1892. The object is to determine the relative value for different crops of the two leading potash salts, muriate and sulfate, when used in equal quantities continuously upon the same land. The field contains eleven plots, of one-eighth of an acre each. Six of these have been yearly manured with muriate

of potash and five with the high-grade sulfate of potash. These salts were used at the rate of 400 pounds per acre from 1892 to 1899 inclusive; in 1900 and 1901 the rate of application has been 250 pounds per acre. All plots receive yearly an application of fine-ground bone, at the rate of 600 pounds per acre. The crops grown in the field are rotated, and the following have been included: potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans and cabbages. The crops have been almost uniformly large. The results were summarized in the report of last year as follows: —

Among the crops grown, the potatoes, clovers, cabbages and soy beans have with very few exceptions done much the best on the sulfate of potash; while the yield of corn, grasses, oats, barley, vetches and sugar beets has been equally good on the muriate. The *quality* of the crops of potatoes and sugar beets produced on the sulfate of potash plots has been distinctly better than that of the crops produced on muriate of potash. Taking all the crops except the clovers into consideration, if we represent the efficiency of the high-grade sulfate of potash by the number 100 that of the muriate of potash is 98.1. Taking into account only those crops showing the preference for the sulfate of potash, and representing the efficiency of that salt by the number 100, the efficiency of the muriate of potash is 88.6.* The present difference in price between the two salts is only about $5 per ton. The conclusion, therefore, appears to be warranted that, under conditions similar to those prevailing in this experiment, the selection of the sulfate rather than the muriate is wise.

The crops of the past year have been clovers of three kinds, and cabbages.

A. — Clovers (Sulfate v. Muriate of Potash).

The growth of the clover on the sulfate of potash was considerably better than on the muriate. The yields are shown below: —

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* Clovers not included, because weeds have not been separated in harvesting.

Muriate v. High-grade Sulfate of Potash. — Clover Hay per Acre (Pounds).

Variety.	Muriate of Potash.	High-grade Sulfate of Potash.
Common red clover,	6,600	7,387.5
Mammoth red clover,	7,312	7,612.0
Alsike clover (a portion weighed green),	10,840	14,290.0

It should be stated, in commenting upon these results, that the crops, as in former years, were considerably mixed with weeds. The weights, however, while not affording an accurate basis of comparison for determination of the precise effects of the different potash salts on the clovers, are not misleading as to the nature of the effect. This is not magnified by the figures, but rather the reverse, for the reason that where the growth of the clover is less luxuriant the growth of the weeds is proportionally more so.

In this connection attention is called to the fact that two other plots in the field are now in clover which was sown in July. These plots have not been cut, but there is at the present time a great difference in favor of the sulfate of potash in the condition of the clover on the two plots.

In conclusion, concerning the merits of these two potash salts for clovers, it is believed that the sulfate is much the safer. Our experiments with these crops have extended over many years, and while sometimes the yield on the muriate of potash is as great as that on the sulfate, there have been many more instances when the yield on the sulfate has been much the better. The difference in favor of this salt appears to be greater in proportion as the rainfall is abundant. It seems probable that this fact is due to the greater loss of lime, which, in association with the acid of the muriate, is washed out of the soil in considerable quantities whenever climatic conditions favor soil leaching.

B. — Cabbages.

The crop of cabbages on both the potash salts used was good, at the rate per acre of 33,680 pounds on muriate of

potash and 30,600 pounds on sulfate. The yield on the muriate is somewhat better than on the sulfate, — a result which is at variance with results which have been obtained in some previous years. Clearly, climatic conditions have an important influence in determining the manurial effect of these salts.

III. — Fertilizers for Garden Crops. (Field C.)

The experiments upon which the conclusions now presented are based have been in progress since 1891. Up to 1898, chemical fertilizers alone were used. During the past four years stable manure has been applied in equal quantities (at rate of 30 tons per acre) to each of the plots, while the chemical fertilizers have been used in the same amounts and applied to the same plots as at first. The crops grown during this series of years have included all important outdoor garden crops, viz., spinach, lettuce, onions, garden peas, table beets, early cabbages, late cabbages, potatoes, tomatoes, squashes, turnips, sweet corn and celery; and one small fruit, — strawberries. The experiments have been planned with reference to throwing light especially upon two points: —

A. — The relative value of nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen.

B. — The relative value of sulfate of potash and muriate of potash.

These two points will be separately discussed: —

A. — The Relative Value for Garden Crops of Nitrate of Soda, Sulfate of Ammonia and Dried Blood as Sources of Nitrogen.

The three fertilizers used as sources of nitrogen have from the first been applied in such amounts as to furnish equal nitrogen to each plot, and each fertilizer is always applied to the same plot. Each of the nitrogen fertilizers is used on two plots, — on one with sulfate of potash, on the other with muriate. Dissolved bone-black, as a source of phosphoric acid, is applied in equal quantities to all

plots. The results previous to this year were thus summarized in the last annual report: —

Taking into account the periods when chemical fertilizers only were used, and the crops (spinach, lettuce, onions, table beets, garden peas and early cabbages) whose period of growth is the comparatively early part of the season, we find the relative efficiency of the different materials used as the source of nitrogen: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	86.6
Sulfate of ammonia,	83.6

For the same periods, and taking into account those crops (tomatoes, garden beans and sweet corn) making much of their growth after hot weather fairly sets in, we find the relative standing as follows: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	97.8
Sulfate of ammonia,	103.5

For the period since manure has been applied, and taking into account the early crops only (spinach, lettuce, table beets, onions, garden peas and potatoes), the relative standing is: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	88.8
Sulfate of ammonia,	61.7

For the same period, taking into account the aggregate yield of all the late crops (tomatoes, cabbages, turnips, squashes and celery), the relative standing is: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	97.8
Sulfate of ammonia,	91.9

The crops for the past year have been onions, lettuce, table beets, late cabbages, garden peas, celery and English turnips (both as second crops) and strawberries. The average rates of yield per plot for each of the nitrogen fertilizers is shown in the following table: —

Nitrogen Fertilizers compared as Fertilizers for Garden Crops. — Yield per Plot (Pounds).

Average of Two Plots.	Onions.	Lettuce.	Table Beets.		Cabbages.	Garden Peas.		Strawberries.	Turnips.		Celery.
			Roots.	Tops.		Peas.	Vines.		Roots.	Tops.	
Nitrate of soda,	425.0	110.0	151.0	125	868.75	54.1	68.8	41.25	1,167.5	550.0	1,067.5
Sulfate of ammonia,	207.5	40.0	65.3	73	785.50	64.6	81.3	44.87	1,072.5	580.0	455.0
Dried blood,	365.0	97.5	136.0	115	915.50	55.8	67.5	75.46	1,102.5	627.5	945.0

It will be seen that for most of the crops the results are similar to the average results of preceding years. Combining the results of this year with those of previous years, the relative standing of the different fertilizers used as sources of nitrogen is as follows: —

For the early crops, *i.e.*, crops making most of their growth before mid-summer, including onions, lettuce, table beets, garden peas, and strawberries: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	92.7
Sulfate of ammonia,	54.8

For late crops, including cabbages, turnips and celery: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	98.7
Sulfate of ammonia,	77.5

The superiority of nitrate of soda as a source of nitrogen for most garden crops, indicated by the results of preceding years, is still further confirmed in the case of most of the crops by the results of this year. Nitrate of soda, among the various nitrogen fertilizers, furnishes a pound of nitrogen at present prices at lower cost than any other fertilizer which is fairly available. These facts make it evident that it should usually be selected, especially for early crops. Experiments here and elsewhere indicate that, if soil on which sulfate of ammonia is used is heavily limed, its rate of availability is much increased. The purchase and application of lime, however, adds to the cost of the

crop; and, even disregarding the lime, as the pound of actual nitrogen at current prices for sulfate of ammonia costs more than the same quantity at current prices for nitrate of soda, the latter is clearly economically preferable, if simply equally effective. We have found it more so.

B. — The Relative Value of Sulfate and Muriate of Potash for Garden Crops.

The history of the plots where these two potash salts are under comparison has been given under section *A*. The crops are of course the same as those which have been named under that section. Each potash salt is used on three plots, *i.e.*, with each of the three nitrogen fertilizers. The results of the past year are shown in the following table: —

Sulfate and Muriate of Potash compared as Fertilizers for Garden Crops. — Yield per Plot (Pounds).

Average of Three Plots.	Onions.	Lettuce.	Table Beets.		Cabbages.	Garden Peas.		Strawberries.	Turnips.		Celery.
			Roots.	Tops.		Peas.	Vines.		Roots.	Tops.	
Sulfate of potash, high grade.	360	86.66	116.3	100.0	827.0	54.3	68.3	47.74	1,091.7	536.7	831.7
Muriate of potash, . .	305	78.33	118.1	108.7	886.2	62.1	76.7	59.98	1,136.7	635.0	813.3

In commenting upon the results obtained in comparing these two fertilizers last year, the following tables were presented: —

Before Manure was used, — 1891–97.

Fertilizer.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash, ...	100.0	100.0
Muriate of potash, ...	91.3	91.5

After Manure was used, — 1898–1900.

Fertilizer.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash, ...	100.0	100.0
Muriate of potash, ... -	86.1	98.8

Including the crops of the past year, the standing is shown below; under the headings early and late crops respectively are included those specified in section *A*: —

Fertilizer.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.0	100.0
Muriate of potash,	92.6	103.0

It will be noticed that for the early crops the sulfate of potash is superior to the muriate, while for the late crops, including those of this year, muriate stands slightly ahead. This has not been the case in earlier years, but the nature of the difference has always been the same. The sulfate should undoubtedly be preferred for early crops, unless the soil is heavily limed, in which case results here and in many other places indicate that the muriate may answer equally well.

IV. — The Relative Value of Different Phosphates. (Field F.)

The object of this experiment is to determine whether it is more profitable to employ cheaper natural phosphates, or one of the higher priced dissolved phosphates. The articles compared are dissolved bone-black, ground South Carolina rock, ground Florida rock, Mona guano and phosphatic slag. These phosphates were applied during the years 1890 to 1893, on the basis of equal money's worth. The amounts of phosphoric acid supplied to the several plots on this basis have of course varied widely, as the prices of the materials differ greatly. The actual amounts of phosphoric acid supplied the several plots are as follows: —

Plots.	Fertilizer.	Pounds.
Plot 1,	Phosphatic slag,	96.72
Plot 2,	Mona guano,	72.04
Plot 3,	Ground Florida rock phosphate,	165.70
Plot 4,	Ground South Carolina rock,	144.48
Plot 5,	Dissolved bone-black,	45.36

Since 1893 no phosphate has been applied to any part of the field. The object in view in withholding phosphates has been to test the lasting qualities of the several materials. At the beginning of the present season, supposing the crops harvested to have been of average composition, and that there has been no loss of phosphoric acid by leaching (which is improbable), there must have remained of the total phosphoric acid applied to the several plots the following amounts in each: —

	Pounds.
Phosphatic slag,	53.6
Mona guano,	29.7
Florida phosphate,	132.4
South Carolina rock phosphate,	102.0
Dissolved bone-black,	9.5

Throughout the entire period of the experiment (1890 to date), materials supplying nitrogen and potash have been applied in equal amounts to all plots. Since 1893 the quantities applied have been made very large, in order to make it certain that the crops grown may find in the soil all the nitrogen and potash they can possibly need. All the plots in the field were limed at the rate of one ton to the acre of quick-lime, slaked, spread after ploughing and deeply worked in with a harrow in the spring of 1898. The crops which have been raised on the field previous to this year, in the order of their succession, are potatoes, wheat, serradella, corn, barley, rye, soy beans, Swedish turnips, corn, oats and cabbages. Representing the yield on the plot giving the highest returns by 100, the relative efficiency* of the different phosphates at the beginning of this year stood as follows: —

	Per Cent.
Phosphatic slag,	100.0
Ground South Carolina rock,	92.3
Dissolved bone-black,	90.7
Mona guano,	88.3
Florida phosphate,	71.5

Taking into account the crops grown since 1895, when for the first time a plot to which no phosphate was applied was included, the phosphates have the following relative rank: * —

* Swedish turnips, grown in 1897, have not been included in computing these percentages as that crop was affected by disease not apparently connected with the fertilizers used.

	Per Cent.
Ground South Carolina rock, ...	100.0
Phosphatic slag, ...	99.0
Dissolved bone-black, ...	97.7
Mona guano, ...	95.4
Florida phosphate, ...	64.2
No phosphate, ...	55.4

The crop this year has been oats, of the Early Race-horse variety. The soil was well prepared, the crop sown May 6. The growth was, so far as could be seen, unaffected by accidental conditions. There were, however, more weeds on plots 3 and 4 than elsewhere; and, as it was impossible to separate these completely in handling the crop, some of them were weighed with the straw. The figures representing weights of straw for these plots, especially for plot 3, on which weeds were most abundant, are therefore without doubt to some extent misleading. The several plots produced yields at the following rates per acre: —

Comparison of Phosphates. — Yield of Oats per Acre.

Plots.	Fertilizer.	Grain (Bushels).	Straw (Pounds).
Plot 0, ...	No phosphate, ...	18.24	365
Plot 1, ...	Phosphatic slag, ...	21.00	1,208
Plot 2, ...	Mona guano, ...	17.59	1,059
Plot 3, ...	Ground Florida rock, ...	13.98	1,447
Plot 4, ...	Ground South Carolina rock, . .	19.96	1,201
Plot 5, ...	Dissolved bone-black, ...	16.63	1,058

Representing the yield of grain on plot 1 by the number 100, the relative standing of the other plots is shown by the following table: —

Plots.	Fertilizer.	Per Cent.
Plot 0, ...	No phosphate, ...	86.8
Plot 1, ...	Phosphatic slag, ...	100.0
Plot 2, ...	Mona guano, ...	83.8
Plot 3, ...	Ground Florida rock, ...	66.6
Plot 4, ...	Ground South Carolina rock, ...	95.0
Plot 5, ...	Dissolved bone-black, ...	79.2

The plots which stand highest this year are the same as those standing highest in the general averages which have been shown above, viz., the ones receiving phosphatic slag and ground South Carolina rock phosphate. The low standing of the plot which received Florida phosphate is, as in former years, very striking; it stands this year below the no-phosphate plot. It should be remembered, however, that the latter has not been included in this experiment as long as the Florida phosphate plot; and it may well be that the original store of phosphoric acid in the soil of the no-phosphate plot is to a much less degree exhausted than is the case on the other plots. It must be concluded that the phosphoric acid supplied by the Florida phosphate is in a form of combination rendering it exceedingly unavailable.

In the writer's opinion, the oat crop is a much less certain indicator as to the condition of the soil as regards available phosphoric acid than are the crops belonging to the cabbage and turnip family. This is indicated by the fact that the differences in yields with oats this year are much less than were the differences with turnips and cabbages. As the turnips, as already stated, were badly affected by disease, figures for this crop are not presented. The relative yields with cabbages last year were as follows: —

	Per Cent.
South Carolina rock phosphate,	100.0
Dissolved bone-black,	73.0
Phosphatic slag,	60.0
Mona guano,	55.3
Florida rock phosphate,	14.7
No phosphate,	6.9

It should be noticed that the relative position of the several phosphates is nearly the same as this year, but the differences are far greater.

In conclusion, attention is called to the fact that the crops on this field in recent years have not been satisfactory in amount, even on the best plot. The fact that no phosphoric acid in any form has been applied during the last nine years sufficiently accounts for the relatively small yields. Our results, however, indicate a relatively high degree of availability for the phosphoric acid contained in the South Carolina rock and in phosphatic slag. There can

be no doubt that profitable crops of most kinds can be produced by liberal use of these natural phosphates; and in a long series of years there would be a considerable money saving in depending, at least in part, upon these rather than upon the higher-priced dissolved phosphates. It may, however, be doubted whether, under the conditions prevailing in ordinary farm or garden practice, it is ever wise to depend exclusively upon the natural phosphates. The best practice would probably be found to consist in using one of these in part, and in connection with it a moderate quantity of one of the dissolved phosphates.

V. — The Comparison of Phosphates on the Basis of Equal Application of Phosphoric Acid.

The phosphates under comparison on this basis include apatite, South Carolina rock phosphate, Florida soft phosphate, phosphatic slag, Tennessee phosphate, dissolved boneblack, raw bone, dissolved bone, steamed bone and acid phosphate. The experiments have been in progress five years, each phosphate being applied yearly to the same plot. There are three no-phosphate plots, which serve as a basis for comparison. The plots are one-eighth of an acre each in area.

The phosphates yearly applied are used in quantities sufficient to furnish actual phosphoric acid at the rate of 96 pounds to the acre. All plots are manured alike with materials furnishing nitrogen and potash in available forms and in equal amounts to each. The materials used furnish nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. The preceding crops have been: corn, cabbages, corn, and in 1900 oats for hay, and Hungarian grass, also cut for hay. The yields of all these crops have been large, even on the three plots in the field which received no phosphate. The results have been rendered somewhat obscure by the natural variation in the productiveness of the plots in different parts of the field. Plot 1, which receives no phosphoric acid, is naturally much more fertile than any other plot in the field, and in estimating the significance of the results this plot should be

disregarded. The crop for the present year has been onions. As has been the case throughout this part of the State, the onion crop suffered from blight. Our yields of sound and merchantable onions are therefore comparatively small. The results are shown in the table: —

Onions on Plots manured with Equal Amounts of Phosphoric Acid.

Plots.	Fertilizer.	Onions (Bushels per Acre).	Scallions (Pounds per Acre).
Plot 1,	No phosphate,	278.5	1,280
Plot 2,	Apatite,	222.3	1,840
Plot 3,	South Carolina rock phospate,	235.4	1,800
Plot 4,	Florida soft phosphate,	150.6	2,280
Plot 5,	Phosphatic slag,	251.8	1,160
Plot 6,	Tennessee phosphate,	205.7	1,720
Plot 7,	No phosphate,	141.4	2,000
Plot 8,	Dissolved bone-black,	209.5	600
Plot 9,	Raw bone,	252.3	640
Plot 10,	Dissolved bone meal,	213.2	600
Plot 11,	Steamed bone meal,	187.8	560
Plot 12,	Acid phosphate,	187.8	920
Plot 13,	No phosphate,	123.4	1,800

The conclusions stated last year were as follows: —

1. The phosphatic slag evidently furnished phosphoric acid in an exceedingly available form, the yield this year being almost equal to that on the dissolved bone-black.

2. The Florida soft phosphate is apparently a very inferior material, the phosphoric acid evidently becoming available only with great slowness.

3. Steamed bone meal appears to be inferior in availability to raw bone meal.

The results of this year are in most particulars similar. Phosphatic slag, it is true, is exceeded, by a small fraction of a bushel of merchantable onions, by raw bone meal, but it gives a larger total crop. Dissolved bone-black stands relatively lower than last year. Raw bone meal, as last year, is superior to steamed bone meal. The Florida soft

phosphate gives a very inferior crop, — the poorest, indeed, in merchantable onions of any phosphate used. This result is strikingly confirmatory of the results obtained in the field where phosphates are under comparison on the basis of equal money's worth.

VI. — Comparison of Different Potash Salts for Field Crops. (Field G.)

Since 1898 the following potash salts have been under comparison for various field crops: kainite, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. Each is applied annually to the same plot, and all are used in such quantities as to furnish equal potash to each plot. All plots are equally manured with materials furnishing nitrogen and phosphoric acid. There are forty plots, in five series of eight plots each, each series including a no-potash plot and one for each potash salt used. The area per plot is about one-fortieth of an acre. The crops the present year have been wheat on one series of eight plots, and corn of four different varieties on the other four series.

A. — Wheat.

The variety of wheat was the Turkish Red Winter, seed of which was received from the United States Department of Agriculture. The soil is rather heavy, and the seed was received so late that it was got in somewhat later than desirable, viz., October 13. It was sown broadcast at the rate of five pecks to the acre, and covered with the Acme harrow. Owing no doubt chiefly to the lateness of sowing, there was some winter-killing. This was most severe on the no-potash, kainite and the two sulfate plots. The whole field was harrowed about the middle of May. The growth was unusually healthy for this section, although all plots were slightly affected by rust. The grain was plump, hard and of good quality. The yields were as follows: —

Wheat. — Yield per Acre.

Plots.	Potash Salt.	Grain (Bushels).	Straw (Pounds).
Plot 1, ...	No potash, ...	8.19	1,609
Plot 2, ...	Kainite, ...	10.43	1,475
Plot 3, ...	High-grade sulfate of potash, . .	14.15	1,877
Plot 4, ...	Low-grade sulfate of potash, . .	14.15	2,595
Plot 5, ...	Muriate of potash, ...	15.64	1,877
Plot 6, ...	Nitrate of potash, ...	16.38	3,083
Plot 7, ...	Carbonate of potash, ...	14.89	2,458
Plot 8, ...	Silicate of potash, ...	17.13	2,055

B. — Corn.

As already stated, the corn was of four varieties. These varieties were as follows: Eureka, a large dent corn, seed obtained from Ross Bros.; Boston Market Ensilage, a large dent variety, seed obtained from Joseph Breck & Sons; Leaming Field, a moderately large dent variety, seed obtained from Gregory; Rural Thoroughbred, a large and late white flint variety, seed obtained from Landreth. All varieties were planted June 6. The field was given good care throughout the season, growth was normal and healthy, unaffected by accidental conditions which influenced results, though all varieties were somewhat broken down by a storm which occurred on September 11. The corn was cut September 13 and 14, and weighed within twenty-four hours. The average for the several fertilizers was as follows: —

Corn. — Average Yield of Four Varieties.

Potash Salt.	Pounds per Acre.
No potash, ...	37,810
Kainite, ...	40,610
High-grade sulfate of potash, ...	37,530
Low-grade sulfate of potash, ...	39,375
Muriate of potash, ...	40,490
Nitrate of potash, ...	40,435
Carbonate of potash, ...	40,155
Silicate of potash, ...	39,240

The only feature of the results to which especial attention is called is the comparatively large yields obtained on the muriate and nitrate, and the good yields on the compara-

tively new fertilizers, carbonate and silicate, which it would seem must possess a high degree of availability.

VII. — Varieties of Ensilage Corn compared.

The varieties of ensilage corn used in the comparison of potash salts, viz., Eureka, Boston Market, Leaming Field and Rural Thoroughbred, were grown under conditions which make it possible to compare them accurately the one with the other; and this comparison seems worth while, on account of the diversity in the practice of farmers, many of whom cultivate excessively large and late varieties of ensilage corn, on account of the heavy yields obtained. The aggregate yield of the varieties under trial was at the following rates per acre: —

	Pounds.
Eureka,	47,960
Boston Market,	38,200
Leaming Field,	34,520
Rural Thoroughbred,	36,150

The following notes were taken on the several varieties just previous to harvest: —

Eureka: a late dent; average height, about 15 feet; very heavily leaved; stalks, 1¾ to 2 inches in diameter; ears just forming.

Boston Market: late dent; height, 11 to 12 feet; stalks, 1½ to 1¾ inches in diameter; ears large, roasting stage; leaves quite abundant.

Leaming Field: medium dent; average height, 10 feet; leaves comparatively few; stalks medium; ears large, beginning to dent; the earliest of the four varieties.

Rural Thoroughbred: late white flint; average height, about 10 feet; stalks large, many 1¼ inches in diameter; heavily leaved; a few suckers (these increase weight but little, and are troublesome to handle); ears large, heavy, often two per stalk; not quite in milk.

The Eureka, giving the best yield, at the rate of almost 24 tons to the acre, would be preferred by many farmers, but in view of the results of analyses it seems doubtful whether this preference is justified by the facts. The table shows the total food substance per acre afforded by each of the varieties: —

Field G. — Varieties of Ensilage Corn, Food Substance per Acre (Pounds).

Variety.	Dry Matter.	Ash.	Protein.	Crude Fibre.	Nitrogen-free Extract Matter.	Fat.
Eureka,	8,944	468.7	613.5	2,951.0	4,790.0	120.8
Boston Market,	6,864	369.3	505.9	2,183.0	3,701.0	104.3
Leaming Field,	7,524	343.9	616.2	1,839.5	4,547.0	176.8
Rural Thoroughbred,	7,923	423.1	626.7	2,140.0	4,614.0	118.8

Examination of the table shows that the variety giving the heaviest yield (green weight) also furnishes the greatest number of pounds total dry matter; but when we compare the figures of the other columns in the table, it will be seen that this excess of dry matter is made up entirely of fibre and nitrogen-free extract, which are the least valuable constituents. In total yield of protein (the most valuable constituent) the Eureka is exceeded by two varieties, — Leaming Field and Rural Thoroughbred; in yield of fat it is much exceeded by the Leaming Field. It would seem the last-named variety, though giving the smallest yield, should be preferred. One pound of digestible fat is commonly considered to have a food value equal to two and one-half pounds of digestible fibre, or extract matter. Fat is commonly equally as digestible as nitrogen-free extract, and is less affected by the fermentations which go on in the silo than are the starches and sugar (extract matter). It is more digestible than fibre. In corn which is approaching maturity the proportion of starch is comparatively high; this food substance is at that time abundantly stored in the grain. As corn approaches maturity, while the starch increases, the proportion of sugar in the juice of the plant decreases. Sugar in green corn fodder is a valuable food substance, but in the silo the sugar is largely converted into acid, and acid has no food value. Starch, while it may suffer some loss in the silo, is far less affected than is sugar. Other things being equal, the immature corn will make, under average silo conditions, a more acid silage than corn which is nearer ripe. The large proportion of water in immature corn, as well as the relatively large amount of sugar, favor develop-

ment of acid. Silage from immature corn, then, is likely to be excessively sour, and is for that reason less desirable than silage from more mature corn.

The chief points, then, which may be urged against the selection of excessively late varieties of corn for ensilage, are as follows : —

1. Much greater bulk and water in proportion to actual food value.

2. Greater probable waste in the manger, on account of the refusal of the animals to eat the very thick and coarse stalks.

3. Such corn, while furnishing more dry matter, contains in larger proportion the less valuable food substances (fibre and sugar) and a smaller proportion of protein, fat, and (though not proved by our analyses) we may safely say starch as well.

4. The immature corn produces a very sour silage, on account of the relatively large proportion of sugar and of water.

5. Though this point is not always important, grass and clover are apt to make but a poor start when seeded in fields planted with excessively large and late varieties. As a large proportion of farmers in some sections now usually seed in ensilage corn, this point should not be disregarded.

VIII. — Soil Tests.

During the past season two soil tests have been carried out on our own grounds, both in continuation of previous work upon the same fields. The same kinds of fertilizers have been applied to each plot, and in the same amounts as last year. The fertilizers in these experiments are used in accordance with the co-operative plan for soil tests adopted in Washington in 1889. Each fertilizer, wherever employed, is applied at the same rates per acre. The following table shows the kinds and usual amounts : —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone-black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 400 pounds.
Lime, 400 pounds.
Manure, 5 cords.

A. — Soil Test with Grass. (South Acre.)

This acre has been used in soil tests for thirteen years, beginning in 1889. The crops in successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn, followed by mustard as a catch-crop, rye, soy beans, white mustard, corn, corn, and grass and clover in 1900. The field has not been ploughed this year but received fertilizers as usual. During the entire thirteen years four of the fourteen plots have received neither manure nor fertilizer; three plots have received yearly a single important manurial element, viz., one of them nitrogen, another phosphoric acid and another potash, — every year the same; three have received each year two of these elements; one has received all three yearly; and one each has yearly lime, plaster or manure. Much of the field, having been either entirely unmanured or supplied with only a portion of the elements ordinarily considered as essential, is now much exhausted. The four nothing plots this year produced an average yield of 375 pounds of hay to the acre at the first cut and 313 pounds at the second cut. The table shows the rate of yield of the several plots: —

Hay and Rowen. — South Acre Soil Test, 1901.

Plots.	Fertilizers used.	Yield per Acre (Pounds).		Gain or Loss per Acre, compared with Nothing Plots (Pounds).	
		Hay.	Rowen.	Hay.	Rowen.
1	Nitrate of soda,	900	550	+500	+310
2	Dissolved bone-black,	300	370	—100	+130
3	Nothing,	400	240	-	-
4	Muriate of potash,	600	700	+233.33	+450
5	Lime,	500	360	+166.67	+100
6	Nothing,	300	270	-	-
7	Manure,	3,600	2,700	+3,300	+2,340
8	Nitrate of soda and dissolved bone-black.	1,200	530	+800	+170
9	Nothing,	400	360	-	-
10	Nitrate of soda and muriate of potash,	2,100	900	+1,700	+533.50
11	Dissolved bone-black and muriate of potash.	1,900	1,500	+1,500	+1,126.67
12	Nothing,	400	380	-	-
13	Plaster,	200	200	—200	—180
14	Nitrate of soda, dissolved bone-black and muriate of potash.	3,300	1,100	+2,900	+720

The effect of each of the three elements of plant food — nitrogen, phosphoric acid and potash — is more clearly brought out in the tables which follow: —

	Results of the Addition of Nitrogen to —				
	Nothing.	Dissolved Bone-black.	Muriate of Potash.	Dissolved Bone-black and Potash.	Average Result.
Hay (pounds per acre), .	+500	+900	+1,466.67	+1,400	+1,066.67
Rowen (pounds per acre), .	+310	+40	+83.33	—406.67	+26.67

Value of increase, ... $8 59
Financial result (gain), ... 5 39

	Results of the Addition of Phosphoric Acid to —				
	Nothing.	Nitrate of Soda.	Muriate of Potash.	Nitrate and Potash.	Average Result.
Hay (pounds per acre), .	—100	+300	+1,266.67	+1,200	+666.67
Rowen (pounds per acre), .	+130	—140	+676.67	+186.67	+213.33

Value of increase, ... $7 04
Financial result (gain), ... 3 84

	Results of the Addition of Potash to —				
	Nothing.	Nitrate of Soda.	Dissolved bone-black.	Nitrate and Dissolved Bone-black.	Average Result.
Hay (pounds per acre), .	+233.33	+1,200	+1,600	+2,100	+1,283.33
Rowen (pounds per acre), .	+450	+233.33	+996.67	+550	+555

Value of increase, ... $14 71
Financial result (gain), ... 11 51

	Results of the Addition to Nothing of —			
	Manure.	Complete Fertilizer.	Plaster.	Lime.
Hay (pounds per acre), ...	+3,300	+2,900	—200	+166.67
Rowen (pounds per acre), ...	+2,430	+720	—180	+100
Value of increment, ...	$45 84	$28 96	-	$2 12
Value of decrease, ...	-	-	$3.04	-
Financial result, ...	$20 84*	$19 36*	$4 84†	$0 92*

* Gain. † Loss.

It will be noticed that the employment of nitrate of soda alone results in a considerable increase both in the first and second cuttings, but its effect in increasing the crop is comparatively small here, no doubt because the soil of that plot must be quite deficient in both phosphoric acid and potash. It will be noticed that the increase produced by the nitrate of soda is greater where it is used with other fertilizers. It gives the greatest increase where used with potash alone, though much the best crop is secured where it is used in combination with both potash and dissolved bone-black. The effect of the dissolved bone-black when used alone amounts to nothing; when combined with potash, or with both nitrate and potash, it appears to be very useful. This is undoubtedly due to the fact that its presence is favorable to the growth of clover, which, as will be seen from the tables below, is very abundant on those plots where bone-black and potash are used together. The ability of clover to thrive in the presence of suitable amounts of bone-black, potash and lime is well known. The crops on the plot where the dissolved bone-black and potash have been so long used, and without any addition of either manure or fertilizer which furnishes nitrogen during the entire thirteen years, afford a striking object lesson. Here we have a yield at the rate of 1,900 pounds of hay to the acre in the first crop and 1,500 pounds in the second. Such crops are far above the average under much more expensive systems of manuring. They are accounted for by the capacity which clover grown under such soil conditions as must exist on this plot possesses to draw the needed nitrogen from the air. It will be noticed that the potash alone gives but a moderate crop, but when used in combination with either of the other fertilizers or with both of them the result is a large increase. As will be seen from the table below, the plots where the potash is used are characterized by relatively large percentages of clover, while there is no clover on the plots to which no potash has been applied. Especially striking is the large increase in the rowen crop where potash is used in connection with dissolved bone-black, — an increase due almost

entirely to the large percentage of clover found on that plot. Attention is further called to the fact that the first cutting of hay on the plot receiving nitrate, dissolved bone-black and potash is almost equal to that on the plot which has yearly received a dressing of barnyard manure at the rate of 5 cords per acre.

The analysis of the manure used is shown below: —

	Per Cent.
Water,	66.61
Total phosphoric acid,	.40
Potash,	.61
Nitrogen,	.52

At the rate at which it was applied, the manure supplied, per plot: nitrogen, 4.86 pounds; phosphoric acid, 3.74 pounds; potash, 5.70 pounds. The fertilizers used on plot 14 supplied: nitrogen, about 1.2 pounds; phosporic acid, about 1.6 pounds; potash, 4.0 pounds.

As was stated in the last annual report, this field was seeded with mixed grass and clover seeds. The clover soon disappeared from all except those plots to which potash has been yearly applied. In order more clearly to show the relation of the fertilizers to the growth of the clover, the product of an average square yard was carefully cut in June and separated into three parts in each case, viz., grass, clover and weeds (including all plants other than true grasses and clover). The material thus secured was allowed to dry until November 16. It was then weighed, with results shown below: —

Effect of Fertilizer on Proportion of Clover. — Product of One Square Yard, Air Dry.

	No Fertilizer.	Nitrate of Soda.	Dissolved Bone-black.	Muriate of Potash.	Nitrate and Dissolved Bone-black.	Nitrate and Muriate of Potash.	Dissolved Bone-black and Muriate of Potash.	Nitrate, Dissolved Bone-black and Muriate of Potash.
Grass (grams),	28.7	84.2	22.6	49.80	74.5	76.5	131.5	133.5
Clover (grams),	–	–	–	30.50	–	45.0	108.0	75.5
Weeds (grams),	–	2.8	–	–	–	–	–	–
Percentage of clover,	–	–	–	37.98	–	37.0	45.1	36.1

When it is remembered that the clover seed which was sown in large quantities came up abundantly upon all plots, it is surely striking that it should have entirely disappeared from every plot except those on which the potash fertilizers have been applied.

B. — Soil Test with Onions (North Acre).

This experiment was conducted upon land which has been used twelve years in soil test work. Each year each plot in the field has been manured in the same manner. The last four crops have been onions, and during the time that the field has been used in experiments with onions it has received double the quantities of fertilizers usually used in soil tests; viz., for each fertilizer, wherever it is used, at the following rates per acre: nitrate of soda, 320 pounds; dissolved bone-black, 640 pounds; muriate of potash, 320 pounds. The plots in this field are long and narrow, about 210 feet by 10½ feet. One-half of each plot was limed in the spring of 1899 at the rate of one ton per acre of quick-lime, slaked, spread evenly after ploughing and harrowed in. The crops grown in this field previous to the onions, in the order in which they have been raised, are: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and rutabaga turnips, and potatoes. The variety of onions grown this year was Danvers Yellow Globe. The seed germinated well; but the plants on most of the plots made little growth, and many soon died, especially on the unlimed portions of plots which had received an application of muriate of potash, or nitrate of soda, or a combination of these without bone-black. The following tables show the results, bulbs and tops being weighed together: —

Onions. — North Acre Soil Test, 1901.

Plots.	Fertilizers used.	Yields per Acre of Bulbs and Tops (Pounds).		Gain or Loss per Acre, compared with Nothing Plots (Pounds).	
		Unlimed.	Limed.	Unlimed.	Limed.
1	Nothing, ...	1,680	3,200	-	-
2	Nitrate of soda, ...	2,400	4,200	+813.33	+1,333.33
3	Dissolved bone-black, . .	1,880	2,600	+386.67	+66.67
4	Nothing, ...	1,400	2,200	-	-
5	Muriate of potash, . . .	3,000	11,200	+1,750	+8,930
6	Nitrate of soda and dissolved bone-black.	8,800	8,000	+7,700	+5,660
7	Nitrate of soda and muriate of potash.	2,400	13,800	+1,450	+11,390
8	Nothing, ...	800	2,480	-	-
9	Dissolved bone-black and muriate of potash.	10,000	13,200	+9,050	+10,660
10	Nitrate of soda, dissolved bone-black and muriate of potash.	18,600	22,600	+17,500	+20,000
11	Plaster, ...	1,400	2,960	+150	+300
12	Nothing, ...	1,400	2,720	-	-

Onions.	Results of the Addition of Nitrogen to —				
	Nothing.	Dissolved Bone-black.	Muriate of Potash.	Dissolved Bone-black and Potash.	Average Result.
Unlimed (pounds), . .	+813.33	+7,313.33	—300	+8,450	+4,064.17
Limed (pounds), . . .	+1,333.33	+5,593.33	+2,460	+9,340	+4,681.67

Onions.	Results of the Addition of Phosphoric Acid to —				
	Nothing.	Nitrate of Soda.	Muriate of Potash.	Nitrate and Muriate of Potash.	Average Result.
Unlimed (pounds), . .	+386.67	+6,886.67	+7,300	+16,050	+7,630.83
Limed (pounds), . . .	+66.67	+4,326.67	+1,730	+8,610	+3,683.33

Onions.	Results of the Addition of Potash to —				
	Nothing.	Nitrate of Soda.	Dissolved Bone-black.	Nitrate and Dissolved Bone-black.	Average Result.
Unlimed (pounds), . .	+1,750	+636.67	+8,663.33	+9,800	+5,212.5
Limed (pounds), . . .	+8,930	+10,056.67	+10,593.33	+14,340	+10,980.0

Onions.	Results of the Addition to Nothing of —	
	Complete Fertilizer.	Land Plaster.
Unlimed (pounds),	+17,500	+150
Limed (pounds),	+20,000	+300

The results of this experiment for this year are exactly similar in kind to those of the last two years, but the yield on the limed portion of the plots shows a falling off as compared with last year. A chemical test of the soil taken from this portion of these plots indicated that it is once more acid on all plots where muriate of potash and nitrate of soda have been used. There can be no doubt that the heavy applications of these fertilizers have again brought about conditions such that lime is once more needed. The principal points to which attention is called are : —

1. The need of lime is the most striking where the muriate of potash and nitrate of soda are the only fertilizers used.

2. The necessity for lime is strikingly evident where the muriate of potash alone is used.

3. Where dissolved bone-black is used in connection either with muriate of potash alone or with muriate of potash and nitrate of soda there is apparently far less need of lime. The dissolved bone-black, containing a considerable proportion of land plaster, supplies this element.

4. The best ripened crop was found where the dissolved bone-black was used, and attention is called to the desirability of using either this or acid phosphate freely wherever onions fail to ripen well.

5. The results make it evident that potash in abundance is highly essential for this crop. Potash alone in combination with lime gives a much better crop than either of the other fertilizers alone under similar conditions.

In conclusion, the belief is expressed that the soil of this field would be much benefited by an increase in its store of humus. Having received applications of fertilizers only for twelve years, and not having been in grass for six years, the stock of humus in the soil is very low and its physical con-

dition is poor. It is much inclined to crust, and soon becomes so compact after tillage that aeration is very imperfect. The results of this year lead to the conclusion that the practical advice as to the selection of fertilizers for onions given in the last annual report will be found suited to the conditions existing in a majority of instances.

IX. — Manure Alone *v.* Manure and Potash.

This experiment, intended to illustrate the relative value in crop production of an average application of manure as compared with a smaller application of manure in connection with some form of potash, was begun in 1890. Full accounts will be found in preceding annual reports and summaries in the reports of 1895 and 1900.

The field contains one acre, and is divided into four plots of one-fourth acre each. The crop for the years 1890 to 1896 was corn; for the years 1897 and 1898, mixed grass and clover; for the years 1899 and 1900, corn. For this year the field has been in grass and clover, having been seeded in corn in the latter part of July, 1900. Neither manure nor fertilizer was applied this year previous to the harvesting of the rowen crop, as it was judged that the application of manures would cause the crop to lodge seriously. In previous years plots 1 and 3 have received manure at the rate of 6 cords per acre; plots 2 and 4, manure, a part of the time 3 cords and for the last year 4 cords, and potash. For the last few years potash has been used at the rate of 160 pounds per acre of the high-grade sulfate. The past season was very favorable for the hay crop. The field was cut twice, July 2 and August 28. The yields are shown in the table: —

Yield of Hay and Rowen (Pounds).

Plots.	Hay.	Rowen.
Plot 1,	1,375	370
Plot 2,	1,380	355
Plot 3,	1,170	415
Plot 4,	990	470

It should be noticed that plots 1 and 3 — manure alone — gave most hay, while plots 2 and 4 produced most rowen. This is undoubtedly due to the larger proportion of clover on these plots. Attention has been repeatedly called in previous reports to the fact that the free use of potash invariably tends to increase the percentage of clover in mowings. Combining the yields of hay and rowen, we find that manure alone has produced crops at the rate of 6,660 pounds per acre, while the lesser quantity of manure and potash has yielded 6,390 pounds. Here is a difference at the rate of 270 pounds per acre in favor of the larger quantity of manure alone. It is estimated that the manure alone, if purchased, is applied at the rate of $30 worth to the acre; the lesser quantity of manure and the potash used with it are applied at a cost of $23.60. We have, then, 270 pounds more hay produced where the annual cost of manuring amounts to $6.40 per acre more than where the smaller crop is produced. Our results, then, for the past year are clearly favorable to the lesser manure and potash. The results of the two systems of manuring up to date may be briefly summarized as follows: —

1. The corn crops have been substantially equal in value.
2. The hay crops have been slightly larger on the plots receiving the more liberal application of manure alone; but these increases have been produced at a cost, where manure is estimated at $5 per cord in the field, greater than their value.

X. — Special Corn Fertilizer *v.* Fertilizer Richer in Potash.

The object of this experiment, as has been fully explained in previous reports, is to determine the most profitable combination of fertilizers to be used for the growth of corn in rotation with grass and clover, and especially to test the question as to whether the "special" corn fertilizers offered in our markets have such composition as is best suited for the production of corn under such conditions. The field is divided into four plots, and two of these plots — 1 and 3 — have yearly received an application of mixed fertilizers,

furnishing the same amount of nitrogen, phosphoric acid and potash as would be furnished by 1,800 pounds of fertilizer having the average composition of the "special" corn fertilizers analyzed at this Experiment Station in 1899. This average is as follows: —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The fertilizers analyzed varied widely in composition, the range for each of the elements being shown by the following: —

	Per Cent.
Nitrogen,	1.5- 3.7
Phosphoric acid,	9.0-13.0
Potash,	1.5- 9.5

The other two plots — 2 and 4 — received annually an application of materials practically the same in kind and quantity as those recommended in Bulletin No. 58 for corn on soils poor in organic matter. These plots are supplied with a much larger quantity of potash and with less phosphoric acid than the other plots in the field. The fertilizers applied to the several plots are shown in the following table: —

Fertilizers Used.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	-
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Muriate of potash,	37.5	62.5

During the past year this field has been in grass, having been seeded in the corn crop of last year in the latter part of the month of July. The season has been favorable to the hay crop, and the field has been cut twice, July 1 and August 28. The hay was housed in good condition. The tables show the yields: —

Yield of Hay and Rowen, 1901 (Pounds).

Plots.	Hay.	Rowen.
Plot 1 (lesser potash), ...	1,450	125
Plot 2 (richer in potash), ...	1,460*	260
Plot 3 (lesser potash), ...	1,250	125
Plot 4 (richer in potash), ...	1,460*	255

* Plots 2 and 4 weighed together on account of threatened storm; but, so far as could be determined by the eye, the yields of the two plots were substantially equal.

Average Yields per Acre (Pounds).

Plots.	Hay.	Rowen.
Plots 1 and 3, ...	5,400	500
Plots 2 and 4, ...	5,840	1,030

It will be noticed that the yields both of hay and rowen, but especially of the latter, were considerably heavier on plots 2 and 4 (*i.e.*, the plots which received fertilizer richer in potash) than on the others. The first crop on these plots was excessively heavy, and lodged to a considerable extent. The proportion of clover was much larger than on plots 1 and 3. The fact that the rowen crop on these plots was rather more than double that on the others was due chiefly to this difference in the proportion of clover.

The cost per acre of fertilizers applied at the rates used on plots 1 and 3 exceeds the cost per acre of fertilizers applied at the rates used on plots 2 and 4 by about $4. We have, then, as a result of this year considerably larger yields at less cost. This field has been used continually in this experiment since 1891. The crop was corn for the years 1891 to 1896 inclusive, in 1897 and 1898 the field was in mixed grass and clover, in 1899 and 1900 in corn. The results of this experiment to date may be briefly summarized as follows: —

1. The crop of corn has been substantially equal on the two systems of manuring.

2. The crops of hay have been larger on the plots where more potash has been used, and the quality has been better.

3. The clover is relatively much more abundant on the plots where more potash is used. This difference is much

more striking at the present time than when the field was in grass in 1897 and 1898. In view of the well-known fact that the clover sod when turned is exceedingly favorable for succeeding crops, it is confidently anticipated that the differences in yields under the two systems of manuring will increase from year to year, and that the superiority of the mixture of fertilizers containing more potash will therefore become increasingly evident.

XI. — Experiment in manuring Grass Lands.

The system of using wood ashes, ground bone and muriate of potash, and manure, in rotation upon grass land has been continued upon the same basis as last year. There are three large plots, varying in size between about 2½ and 4 acres. It may be remembered that according to the system followed each plot receives wood ashes at the rate of 1 ton per acre one year; the next year, ground bone 600 pounds, and muriate of potash 200 pounds, per acre; and the third year, manure at the rate of 8 tons. Both this year and last there has been used, on the plots receiving ashes, and ground bone and muriate of potash, respectively, nitrate of soda at the rate of 150 pounds per acre. This year, as last, a small application of nitrate of soda has been made to about one-half of the plot receiving wood ashes after the cutting of the first crop, for the purpose of determining to what extent such application is beneficial to the rowen crop. The system of manuring is so planned that each year we have one plot under each of the three manurings. The barnyard manure is always applied in the fall, the ashes, and the bone and potash, in early spring. The nitrate of soda used on two of the plots was applied to one April 18, to the other April 19. The past season has been favorable to the hay crop. All these plots have been cut three times. The total yields were at the following rates per acre: —

	Pounds.
On barnyard manure,	7,367
On wood ashes and nitrate of soda,	5,817*
On bone, muriate of potash and nitrate of soda,	6,815

* Actual yield, 6,679 pounds; above figure obtained by making reduction equal to increase believed to have been produced by application of nitrate of soda for rowen.

The average yield of the entire area for this year is 6,859 pounds. The average for the period 1893 to the beginning of the present year was 6,615 pounds per acre. The plots when dressed with manure have averaged 6,878 pounds per acre; when dressed with bone and potash, 6,649 pounds; and when receiving wood ashes, 6,309 pounds per acre. The average yields obtained on this field are surely very satisfactory. They are obtained at a cost for fertilizing materials applied which renders the hay crop decidedly profitable.

XII. — Nitrate of Soda for Rowen.

We began last year experiments calculated to show to what extent a small application of nitrate of soda applied after the removal of the first crop of hay would benefit the crop of rowen. The results last year showed increase in the rowen crop sufficient to render the application a paying one. These experiments have been continued this year, and have been carried out on two fields: —

1. On an old sod seeded in 1887, where the prevailing species is Kentucky blue grass, and which received in the spring an application of wood ashes at the rate of 1 ton to the acre and nitrate of soda at the rate of 150 pounds per acre. The first crop was cut June 17. The nitrate of soda was applied to two sub-plots, constituting about one-half of the field, at the rate of 150 pounds per acre on July 3. The results are shown in the table: —

Nitrate of Soda for Rowen. — Yields per Acre (Pounds).

Plots.	Nitrate used.	Rowen, First Crop.	Rowen, Second Crop.	Total Rowen Crop.
Plot 1,	No nitrate,	1,148	627	1,775
Plot 2,	150 pounds per acre,	1,599	732	2,331
Plot 3,	No nitrate,	1,260	711	1,971
Plot 4,	150 pounds per acre,	1,676	880	2,556

The average rates of yield per acre are: —

	Pounds.
No nitrate,	1,873
Nitrate,	2,444

The average increase due to the application of 150 pounds of nitrate of soda is therefore 571 pounds. At the current price for nitrate of soda, this increase has cost a little more than one-half a cent per pound.

2. Nitrate was tried upon a timothy sod seeded in 1899. Four equal plots were laid off, and to two of them nitrate was applied at the rate of 150 pounds per acre. The first crop was cut July 8; the nitrate was applied July 17; the rowen crop was cut September 16. The table shows the calculated results per acre: —

Nitrate of Soda for Rowen. — Yields per Acre (Pounds).

Plots.	Nitrate applied.	Yield of Rowen.
Plot 1,	No nitrate,	436
Plot 2,	150 pounds per acre,	953
Plot 3,	No nitrate,	463
Plot 4,	150 pounds per acre,	463

The average rates of yield per acre were: —

	Pounds.
No nitrate,	449
Nitrate,	709

The average increase is therefore 259 pounds, which, at the current price for nitrate of soda, costs about 1⅙ cents a pound. The use of nitrate for rowen is therefore profitable in the case of the Kentucky blue grass sod, unprofitable in the case of the timothy. Neither the blue grass nor the timothy, however, are varieties characterized by a free or abundant second growth. The results of the application of nitrate of soda for rowen are likely to be better for other varieties, such as orchard grass, the fescues and rye grasses.

XIII. — Experiment in Application of Manure.

Observation of the results obtained for a number of years from the application of manures spread in late fall or winter and allowed to lie upon the surface until spring had

led to the conclusion that an experiment was needed to determine whether that practice is wise. The previous history of one of our fields had left it in such condition that we could compare two methods only of application. This field had previously been divided into five plots, each of which had for some ten years received different manurial treatment. These plots were comparatively wide, and it was proposed to divide each in the middle, designating one-half of each plot north, the other south. The original plots had been numbered 1 to 5. The previous manurial treatment had been as shown in the table: —

Plots.	Fertilizer used.
Plot 1,	Barnyard manure, 10 tons per acre.
Plot 2,	Wood ashes, 1 ton per acre.
Plot 3,	No manure.
Plot 4,	Fine-ground bone, 600 pounds per acre; muriate of potash, 200 pounds per acre.
Plot 5,	Fine-ground bone, 600 pounds per acre; sulfate of potash, low grade, 400 pounds per acre.

In 1899 the entire field was evenly manured with manure from well-fed milch cows. The topography of the field is such that there is considerable slope lengthwise of the plots, although the lay of the land makes it possible that under exceptional circumstances there may also be a little wash from one plot to another. The crop in 1899 and 1900 was corn, — in 1899 for the silo, in 1900, husked; in 1901 the crop was Japanese barnyard millet.

The plan of manuring followed during 1900 and 1901 may be thus described: —

Four of the plots — 1, 2, 3 and 4 — receive an application of carefully saved manure from milch cows at the rate of 10 tons to the acre. Plot 5 receives an application of stable manure at about the same rate. The cow manure when applied is comparatively fresh and unfermented. The four plots receive this manure each at a different date, our practice being to remove the manure from the pits as it accumulates as soon as the quantity made is sufficient for one plot.

Whenever a plot is manured, the loads as hauled are placed alternately one on the north and the other on the south half of the plot. The load for the north half is spread, that for the south half is put into a heap, all the manure for that half being placed in one large, well-shaped heap. The weight of manure for each half is the same. The manure for plot 1 is applied in late fall, plot 2 in early winter, plots 3 and 4 in the order named, at dates still later in the winter. The stable manure used on plot 5 has been handled in a similar way, the application to this plot commonly being made rather late in the winter; and the manure when applied has been partially rotted, and hot and steaming at the time it was hauled. Our practice has been to plough the field in mid-autumn, and then to sow a cover crop, — usually rye. The manure which is put into heaps is spread in spring shortly before the ground is to be planted, and the whole area is immediately ploughed, the manure applied during the winter as well as that just spread from the heaps being at that time turned in. The results for the three years, viz., the first, when all plots were treated alike, and the last two, when the manure was applied as just described are concisely shown in the tables: —

Yield of Corn and Millet, in Pounds per Plot.

Plots.	Previous Manuring.	1899 Corn, Green (Both Halves manured alike).		1900 Corn, Ears and Stover.		1901 Barnyard Millet Hay.	
		North Half.	South Half.	North Half (Manure spread).	South Half (Manure piled).	North Half (Manure spread).	South Half (Manure piled).
1	Barnyard manure, . .	5,995	6,320	1,920	1,983	1,375	1,625
2	Wood ashes, . . .	6,020	5,785	1,825	1,955	1,050	1,380
3	No manure, . . .	2,900	4,215	1,380	1,725	740	1,310
4	Bone and muriate of potash.	5,010	4,590	1,630	1,795	1,040	1,515
5	Bone and sulfate of potash.	4,805	5,470	1,645	2,015	1,130	1,680

Relative Yield of Corn and Millet, in Percentages.

Plots.	1899 Corn (both Halves manured alike).		1900 Corn.		1901 Millet.	
	North Half.	South Half.	North Half (Manure spread).	South Half (Manure piled).	North Half (Manure spread).	South Half (Manure piled).
Plot 1, ...	100	105.4	100	103.4	100	118.1
Plot 2, ...	100	96.1	100	107.1	100	131.4
Plot 3, ...	100	145.3	100	125.0	100	177.0
Plot 4, ...	100	91.7	100	110.4	100	145.6
Plot 5, ...	100	113.8	100	122.5	100	148.7

It will be seen that the two halves of the several plots were not quite even in fertility, as indicated by the yields of the first year, at the start. The greatest difference was found on plot 3. The north half of this plot suffers from spring or ooze water to a greater extent than the south part. We must be cautious, therefore, in attaching importance to the largely increased difference in yield on that half of this plot manured in spring for the past season. It will be noticed, however, that, while there are differences in the degree, there is a marked tendency to increased superiority in favor of spring application on the other plots of the field as well as on this.

This experiment will be continued; but it has seemed wise to call attention to the results so far obtained, for the reason that the conditions on this field as regards the nature of the surface are similar to those existing in the fields on many farms, and for the further reason that the results certainly indicate that there is grave reason to doubt whether application of fresh manure during the winter and allowing it to lie upon the surface until spring is wise. In conclusion, I should perhaps call attention to the fact that, while the difference between the south and the north half of plot 3 may be to a considerable degree due to the different natural conditions, it seems only reasonable to conclude that it may be in part also due to the fact that the fertility of this plot at the start was much lower than that of the others, as it

had been cropped for many years without application of manure or fertilizer of any kind. On the other plots, which had been well manured in preceding years, it would not be strange should a good yield be obtained on the north half, even although the manure spread there during the winter may have suffered serious loss. The fact that the difference between the north and south halves of plot 1 during the past two years is less than on any of the other plots, serves to confirm this view; for it will be remembered that plot 1 had yearly received a fairly liberal application of barnyard manure for a long series of years previous to the beginning of this experiment.

XIV. — Alfalfa as a Forage Crop.

There is at the present time so much interest in alfalfa as a forage crop that attention is called to the fact that the results obtained at this station have been distinctly unfavorable. Alfalfa has been under trial in a small way for a considerable number of years, and we have never succeeded in obtaining results encouraging to its general introduction.

It is well known that alfalfa thrives best on soils where the water level is well below the surface, and where the texture of the sub-soil is not too compact. We have not perhaps an ideal soil for alfalfa on the college estate. It has been tried, however, on a considerable number of fields, some of which it would seem must possess soil with the right characteristics. It is known, further, that for success with alfalfa the soil must be rich in lime. Our soils are not naturally rich in this constituent. In one of the experiments of the past few years which will now be briefly described we have made a heavy application of lime to one-half of the plot.

A. — Alfalfa on Campus Slope.

The field known as campus slope falls off gradually toward the west, affording perfect surface drainage. The surface soil is fine, medium loam, which gives excellent crops of potatoes, corn or clover. The sub-soil to the depth of three or four feet is of the same general character as the surface

soil, though containing, of course, less humus. At the depth of five to six feet begins a somewhat open-textured gravel, — a quality of gravel which makes quick-bedding road material, but which as it lies is not at all of the nature of a hardpan. The water level of this field is well below the surface. In 1899 the field produced a crop of potatoes; for the two previous years it was in mixed grass and clover. It was manured in the spring of 1900, at the rate of 4 cords to the acre; the manure was ploughed in. The plot, which was 40 feet in width and 152 feet long, was divided into two strips, and to one of these lime was applied at the rate of 1½ tons (air-slaked) per acre. After ploughing, fertilizers were applied at the following rates per acre: —

	Pounds.
Sulfate of potash, high grade,	250
Acid phosphate,	400
Steamed bone,	200

The seed was sown in rows ten inches apart on May 22. The plot was hand-weeded and hoed several times throughout the summer. The growth was very slow, and no crop was harvested. This alfalfa passed through the winter in good condition. The plot was lightly harrowed on April 16; on May 1, it was hoed. On May 6, fertilizers were applied in the same amounts as in 1900. Early in the summer it was noticed that the alfalfa was somewhat better on the limed half of the plot. To the west end of both limed and unlimed portions a small application of soil from an alfalfa field in Kansas was made in the spring of 1900. This was for the purpose of testing whether deficiency of bacteria of the right kind was the probable cause of the slow growth of the crop. It was believed that the Kansas soil would furnish these. No particular difference was noticed during the first season; but by the middle of June the past season it could be plainly seen that the growth where the Kansas soil had been spread was superior to that on the other parts of the plot. The plot was cut three times during the season, June 20, July 21 and September 6, each time when in early bloom. The yields per plot were as follows: —

Yield of Alfalfa (Pounds).

	June 20.	July 21.	September 6.	Total Crop.
Without lime, ...	175	70	130	375
With lime, ...	290	105	170	565

The total yield was at the following rates per acre: unlimed, 5,374 pounds; limed, 8,088 pounds. These are green weights, and they represent a very small and unprofitable product. It is of course possible that the poor growth may be largely the result of the absence of bacteria of the right species in suitable numbers; but the yield even on that part of the plots to which the Kansas soil was applied was exceedingly small.

B. — Alfalfa on Field B.

The second plot on which we now have alfalfa is one of those in field B, which has been yearly manured with bone meal at the rate of 600 pounds, and muriate of potash, for the last two years, at the rate of 250 pounds per acre. The soil of this field is a moderately heavy loam. It is tile-drained, by means of one line of tiles running through the middle of the plot; the depth of this drain varies between three and four feet. This plot has recently produced good yields of a number of our common farm crops. The seed was sown on this field in the spring of 1900, in drills, as in the other field, and the crop was very carefully cared for. Nothing was harvested in 1900; but the crop, which was just beginning to bloom, was cut on July 1, as it showed signs of blight. That which was cut was allowed to remain on the ground. It may be here remarked that this practice has been strongly recommended by farmers who have had experience in the growth of alfalfa in New York, where, as here, the crop is somewhat subject to a rust-like blight. The experience of these farmers has led them to conclude that when this blight shows itself the crop must be immediately cut; otherwise, as the leaves are soon destroyed, the vitality of the plants is seriously lowered. Their experience is that, if the crop be promptly cut and allowed

to remain on the ground, a healthy growth soon takes place. Such observations as we have been able to make here indicate that this practice is beneficial.

In the spring of the past year it was found that most of the plants had been lifted from one to two inches by the frosts of winter and spring. Nearly all of them, however, appeared to be alive, and they soon started fairly well, though the growth did not present a good color. On April 13, fertilizers in the usual amounts were applied broadcast. On April 16, the field was harrowed lightly with a smoothing harrow. The crop was cut three times, as follows: —

June 20, just coming into bloom, 2 to 2½ feet in height, the lower leaves beginning to show spots, and turning yellow. Yield, green, 910 pounds.

July 22, in bloom, showing a little blight. Weight, green, 465 pounds.

September 6, beginning to blossom, slightly affected by blight. Weight, green, 440 pounds.

The area of the plot is about two-fifteenths of an acre. The total green weight is 1,815 pounds, which is at the rate of 13,610 pounds per acre. The crop has been once hand-hoed during the past season. The yield of rather less than 7 tons to the acre is much less than could have been obtained from clover, at far lower cost for labor.

In conclusion, these results are presented not as conclusive, but rather to indicate the need of caution on the part of our farmers in the direction of experiments with this crop. True, it is the most valuable forage crop known in the United States in many sections; but it cannot be regarded as by any means certain that it can be made to succeed on the average soils of this State. If successful anywhere, it seems likely to be on deep, mellow soils, of alluvial or drift formation, and where the water table is well below the surface.

XV. — An Old Crop under New Names.

Pearl millet has been advertised by seedsmen for many years, and has been occasionally grown by some of our farmers. Within the past two or three years seedsmen in different parts of the country have advertised what, as a

result of our comparisons, it is concluded is precisely the same variety under new names. The names which have been brought to our attention are Mand's Wonder Forage Crop and Brazilian Millet. Seed offered under these names was procured in preparation for this season's work from the so-called originators or introducers. We also secured seed from some of our prominent seedsmen who in turn had secured it from would-be introducers. The most careful comparisons throughout the entire season failed to disclose any difference. Mand's Wonder and Brazilian millet, so called, appear to be identical in every way with Pearl millet. The latter seed can usually be obtained of seedsmen at about 10 cents per pound, while under the new names the prices charged are much in excess of this figure. Such trials of Pearl millet as have been made here have led to the conclusion that it is not a crop which is likely to prove of any considerable value, unless it may be upon very light, dry and warm soils. The crop has been described and commented on at length in previous reports.

REPORT OF THE BOTANISTS.

G. E. STONE, R. E. SMITH.

The dying of cut-leaved birches.
The present status of chrysanthemum rust in Massachusetts.
The effects of desiccation on soil.
Melon failures.
Stem rots and wilt diseases.
The present status of asparagus rust in Massachusetts.
Sterilization of soil in greenhouses for fungous diseases.

Similar lines of routine work and investigation have been followed in this department as outlined in former reports. During the summer, $400 was expended on repairs and improvements of the building, including part of the greenhouse, and more particularly upon the trucks and tracks utilized for pot experiments. The shed and large unheated greenhouse which were designed for truck experiments have been retracked and concreted, and the original trucks, which were rather primitive in construction, have been remodelled and provided with roller bearings.

Certain species of fungi affecting shade trees and economic crops have been rather common during the year. Among these may be mentioned the *Glœosporium* (*G. nervisequum* (Fckl.) Sacc.), which caused more or less defoliation of the white oak throughout the State. In some instances the foliage was affected to such an extent that half of it fell off which was, as usual, replaced later on by a new growth of leaves. So far as I am aware, no treatment has ever been given the oak for this disease. The fungus appears to be confined to the lower portion of the tree, and no doubt a good spraying of this part with some standard fungicide as soon as the leaves have unfolded and more or less developed

would control this outbreak. This treatment is only recommended where such trees occur in valuable situations, such as on lawns, etc., and where the expense of spraying would equal the utility and value of the trees for shade or æsthetic purposes.

The sycamore has also shown, as it is very likely to each year, more or less defoliation from a similar fungus.

The *Glœosporium* on the maple, previously mentioned in our reports, has been more or less common, causing some injury to the foliage, and a leaf-scorch entirely due to a lack of water supply, causing a drying up of the leaves, has been observed to some extent.

This division frequently received specimens and letters relating to these diseases. They do not constitute very serious maladies, as a rule, and the question of treatment is usually one based upon the utility of the tree under consideration.

Many elm leaves are frequently subject to the fungus known as *Dothidea Ulmi*, (Duv.) Fr., and the European linden in some localities suffers from the effect of a leaf spot (*Cercospora microsora*, Sacc.). Both of these fungi cause the foliage to become spotted and to fall prematurely. It would not be a bad idea once in three or four years to spray badly affected trees, so that they may at least once in a while have a clean crop of foliage, which would exert considerable influence on the growth of the tree.

Other fungi which have been more or less common are the tomato spot or mildew, leaf blight and leaf spot, the quince rust, melon blight, bean anthracnose and asparagus rust. Bacterial rot on cabbage has caused some loss to this crop, and it was noticed in fields that had been planted to cabbages for the first time.

The Dying of Cut-leaved Birches.

The dying of cut-leaved birches became quite a noticeable feature in some places in the eastern part of the State this past summer. The cause of this trouble was incidentally due to borers, but in all probability it was primarily brought about by the drought last season. Probably many

of these trees could have been saved if they had been cut back in time, in order to correlate top growth with that of the roots. Many of our maple trees, when grown on dry, gravelly soil, suffer greatly during a season of drought, and the effect of this suffering is usually increased by the presence of borers in the following years. In cities the restricted growth of roots, caused by pavements, sidewalks, regrading, etc., induces similar pathological conditions in the tree, which are sooner or later followed by the same mischief-makers.

The Present Status of Chrysanthemum Rust in Massachusetts.

The chrysanthemum rust was first noticed in this State in the fall of 1896,* this being the first recorded instance of the appearance of the rust in the United States. The following year it became more widely disseminated in Massachusetts, and has since extended over the larger portion of the United States.† We have never, however, regarded its appearance in this State as a matter of very serious consequence; nevertheless, we have felt it necessary to keep a watchful eye over its presence in our midst. During the past fall we have made an effort to obtain, by means of circulars, whatever information could be secured; and in so far as its occurrence in this State is concerned, this information has borne out our conception of it.

Only one stage of the rust, the uredo, has been found on the plants affected in Massachusetts. In the absence of the other stages which are characteristic of rusts, it might be expected that it would not obtain a very strong foothold. Upon this point Dr. Arthur ‡ writes as follows: "Another circumstance much in the cultivator's favor is the propagation of the disease without the formation of the customary teleuto spores or third stage. Not only does this render the disease far less persistent, but without doubt indicates that it is less vigorous in its attacks. In general, when a rust is confined

* Annual report of the Hatch Experiment Station for 1896, pp. 276-279.

† For details connected with the spread of the rust, etc., consult Bulletin No. 85, October, 1900, Indiana Agricultural Experiment Station.

‡ Bulletin No. 85, p. 128, Indiana Agricultural Experiment Station.

to the uredo forms for a number of generations, its vitality is much reduced, and also its power of injuring the crop. So long as the teleuto spores do not make an appearance in this country, the careful cultivator may feel assured that a moderate amount of timely effort will enable him to rid his establishment of the rust."

From data contained in this circular, it appears that the rust was most prevalent during the years 1897 and 1898, or, in other words, during the first year or two of its outbreak. At this time it became more generally distributed over the State, and of course there was more infection as a whole. It also affected the individual plants more severely during the first outbreak than in the later ones. During the last three years it has shown, as a whole, a marked tendency to decrease in this State. There are, to be sure, individual growers who report an increase; but this increase is perhaps due to their methods of cultivation, and not taking sufficient care to propagate from clean stock. One-third of the growers state that they never had the rust on their plants, and were familiar with it only as they had seen it on other stock, while others have only experienced a slight infection one year. One florist who cultivates 40,000 plants, states that he has not had the rust for three years, or since 1898, and at that time he had it only to a very slight extent. The amount of infection which has been prevalent varies from .1 per cent. to 50 per cent., the latter figure being exceptionally high, for very few have had even 25 per cent. as a maximum amount of infection. The financial damage to the crop is far less than the above, and in most instances it amounts to nothing. The worst injury appears to be to the gardeners' pride, inasmuch as a large percentage of the plants are grown for competition in shows, and even a slight blemish caused by two or three rust pustules on a single leaf, is very annoying to skilful gardeners, who take pride in exhibiting their plants. Most gardeners agree that weak stock is the most susceptible to rust; and if weak, infected plants are allowed to remain in close proximity to strong, healthy ones, they too will subsequently become infected. The variety known as the Queen is singled out as

the one most susceptible to infection. One grower believes that pot-grown plants are more susceptible to rust than those planted in benches.

The remedies suggested by the different growers consist in hand-picking the affected leaves, selecting clean, strong stock, discarding susceptible varieties, and inside culture. These suggestions appear to us very reasonable, and if they are carefully carried out there is at present little reason to doubt that it can be practically eliminated. In regard to the practice of inside culture during the summer, we find that many excellent growers lay much stress on this practice, and from what we have seen of it we consider it very essential in order to obtain plants free from rust. The reason that inside culture results in less infection is probably due to the avoidance of mists and dews on the foliage, hence furnishing less favorable opportunity for rust spores to germinate and cause infection. Care should also be taken to keep all unnecessary water off the foliage in cultivating in the greenhouse. One successful grower makes the following statement: "I have found that when plants were planted in benches in a good house, where plenty of air could be admitted and the soil kept in good physical condition, they were almost never troubled with rust."

Most growers are unanimous in considering the chrysanthemum rust of little consequence, and others look upon it as a thing of the past. There are a few, however, who have not succeeded in subduing it, who still think it a serious disease. Some have resorted to spraying, with results that amount to little more than partial suppression. It appears from our own observations, as well as from those obtained from the most successful growers of this plant, that the proper remedy lies in the judicious selection of healthy, rust-free stock, and inside cultivation. If, however, any of the leaves become infected, they should be removed and burned immediately; and if a plant is badly affected, it should be destroyed. In whatever manner the plants are cultivated, whether in-doors or out-doors, endeavor to keep the dew and moisture off the foliage as much as possible.

The Effects of Desiccation on Soil.

The practice of desiccation or drying greenhouse soils by aid of the heat of the summer sun has been in vogue with us for some time, for the purpose of observing what effect such treatment would have on certain organisms. We have already shown that the *Sclerotinia* or the drop fungus when dried is greatly accelerated in its activity, which increases to a great extent the amount of infection in the succeeding crop of lettuce. The resting spores of many other plants are undoubtedly affected in the same way. There are other effects of drying on the soil which prove very destructive to the development of lettuce plants, although we have not observed this effect upon other species. On lettuce we have observed this repeatedly, and the characteristic results of such drying are manifested in a stunted growth and abnormally colored and worthless crop. The crop scarcely ever attains more than one-third of its size. The texture of the plants is poor, being thick and tough, and inclined to crinkle. That this is caused by desiccation alone is shown by the fact that wherever any drip from the roof fell upon the soil during the summer rains, the plants growing in such places were always normal. Distinctly sharp lines can be observed in a lettuce crop grown under such conditions, owing to the difference in development brought about by desiccation and the presence of a small amount of water due to dripping. Instances have come to our notice where large houses devoted to lettuce have been allowed to become quite dry, with the same result on the crop as noted above. The remedy for this trouble is obvious; namely, not to allow the house to become too dry in summer, but to keep the soil more or less supplied with water. If such drying occurs, the soil can be entirely renovated by applying hot water or steam to it, as we have already shown more than once.

Melon Failures.

No trouble with plants has been more general in New England the past season than that attending the growing of muskmelons. In a great many cases this crop has been a

total loss, and almost without exception the yield has been greatly diminished and the quality of much of the fruit put on the market impaired. In two previous reports (1899 and 1900) we have mentioned this subject, but the trouble has never been so general before. The melon blight described in our report for 1898 was found to be due to a leaf spot fungus of the form called *Alternaria*. This disease appeared in the latter part of August, as the fruit was approaching maturity, and soon killed the vines so completely that the crop in the affected field was a total loss. The trouble was not at the time general throughout the State or even in the immediate region, though it had previously been known in other States. The following year the same disease occurred quite abundantly, and along with it the well-known cucumber anthracnose (*Colletotrichum lagenarium*) was very prevalent on muskmelons and watermelons. This second disease appeared earlier in the season than the *Alternaria*, coming on in July. Between the two diseases and the gradual spread of the trouble the damage to the melon crop was considerably greater in 1899 than during the previous year, and many growers determined to give up this crop. In 1890 more or less trouble was experienced, but not to a marked degree. In that year, however, there appeared in the State upon greenhouse cucumbers for the first time, so far as known, since 1889, the downy mildew of the melon, cucumber and similar plants. During the past season of 1901 complaint has been general from all sections of the State of the complete failure of the muskmelon crop. Examination of the first material sent in revealed the fact that still a third disease had come upon this unfortunate plant, — the downy mildew was abundant on every affected leaf. This proved to be the case in every instance. Affected plants from Amherst, South Amherst, Belchertown, Worcester, Lancaster, Fitchburg, Belmont, Andover and other towns in the State all showed the downy mildew (*Plasmopara cubensis*), while in most instances one or both of the other two fungi were also present on the same leaves.

The consideration of this trouble is therefore a complex one, and each of these destructive fungi must be taken into

account. It must be remembered that each is a definite organism, growing parasitically upon the leaves of the melon, and having its regular course of development.

Taking up each disease separately, we find the *Alternaria* less abundant this year than when it first appeared. No instances have been found, as was certainly the case in 1898, of this fungus alone being the cause of the trouble. It may be mentioned here, however, that specimens of the melon blight, now so prevalent in the extensive Colorado melon districts about Rocky Ford, sent by Mr. H. H. Griffin of the Colorado Experiment Station, show only a fungus apparently identical with our *Alternaria*. All our experience indicates that trouble from this source alone is not to be looked for until comparatively late in the season, — not, probably, before August 1.

The anthracnose (*Colletotrichum*) causes a well-known leaf blight on greenhouse cucumbers, and has been very common on melons the past season. It is more usual on watermelons than muskmelons, having often been the cause of serious damage to the former. On both species it attacks the fruit as well as the leaves, causing spotting and decay. This fungus is not, apparently, as definite in the time of its appearance upon melons as either of the others, but is liable to come on earlier, and generally does so when abundant.

The downy mildew has been comparatively unknown in this State up to the present outbreak. It is now abundant on greenhouse cucumbers, and occurred everywhere on muskmelons last summer. Farther south it has been well known on these plants for some time. The appearance of the fungus on melons is not to be looked for here before August 1 and quite commonly it did not become destructive last season until September 1.

A typical case of the simultaneous occurrence of these three diseases occurred at Mr. A. A. Marshall's place at Fitchburg, Mass., where the growing of muskmelons is made a specialty. Eight acres were grown, all in one field, and all of one variety, the Miller's Cream. At one end of the field the ground was slightly rising, and on this portion the same crop had been grown the preceding year, the rest of

the field being new to melons. About July 22 it was first noticed that a blight was appearing on the vines on the old ground. This did not increase very rapidly or cause any serious damage for some time. When visited, on August 17, picking had just commenced, and the crop was mostly in excellent condition. In the most affected part a few plants were dead or had been pulled out, and many leaves were spotted; some of the fruit also showed spotting and decay. Examination of the badly affected plants, *i.e.*, those which had been earliest attacked, showed the presence of the anthracnose in great abundance, some *Alternaria*, while the downy mildew appeared to be just coming on. The decay of the fruit was due entirely to the anthracnose. From this time on the trouble spread rapidly to other parts of the field, and in this later attack the mildew was almost entirely the cause of the trouble. In other places also, where no disease appeared until about September 1, the rapid destruction which followed was due to the same cause.

From all the cases reported it is evident that, except for the rather unusual case of the anthracnose becoming abundant in July, the chief trouble with the melon crop comes on about September 1, or in the last days of August, just as the fruit begins to mature. The appearance of a badly blighted field is a most discouraging one to the melon grower, the ground being covered with good-sized but mostly flavorless worthless melons among the dead vines. It therefore comes about that a saving of the vines for two weeks at this time is of supreme importance, and even one week means often the difference between profit and loss to the grower.

Treatment. — In order to gain this period in the life of the plant, the most obvious methods are by getting an early start, by the use of early varieties, and by protecting the plant by spraying. Each of these is of practical importance. The first is often practised by starting the plants in hot-houses or frames, and transplanting later to the open field. This method has been used with promising results, and deserves a trial wherever practicable. The choice of varieties is largely a matter of personal taste in this crop,

many growers having their own strains, from which they would depart only with great reluctance. It can only be said that the earliest varieties which are otherwise satisfactory should be grown. From the present outlook, the early fruit must form the bulk of the melon crop.

Spraying. — Considerable success in preventing the attacks of all these fungi has been obtained in various experiments and places by spraying melons and cucumbers. No very extensive results have been obtained, however, with the melon crop in this State. Mr. Marshall's fields were sprayed seven or eight times during the season with various copper fungicides. All the plants were sprayed, so that it is impossible to say just what was gained, and whether the anthracnose which appeared in July would otherwise have proved more destructive. Judged by the case described in our 1900 report, there was a decided gain in this respect. Certainly Mr. Marshall's vines kept alive some time longer than the average in the State or vicinity, and the spraying appeared to have been of advantage. Mr. L. W. Goodell, the Pansy Park seedsman, sprayed with Bordeaux mixture, and in his field a gain of from one to two weeks in the life of the most thoroughly sprayed portions was plainly apparent. Thorough spraying of melons is difficult, for two reasons, — the prostrate position of the plant, making it almost impossible to spray the under side of the leaves, and the rough, hairy surface of the leaf, to which the spray does not readily adhere.

At present the following recommendations seem advisable for this trouble: try, by the methods suggested above, to mature the crop as early as possible; spray with Bordeaux mixture with great thoroughness throughout the season, beginning as early as July 1.

Stem Rots and Wilt Diseases.

Troubles of this sort, in which affected plants show a wilting and withering of the leaves, caused by a more or less rapid decay of the stem, appear to be largely on the increase in cultivated plants. Three such diseases are of special importance at present, owing to their rapid increase.

These are the stem rots of the chrysanthemum, carnation and aster, all of comparatively recent occurrence, but becoming more and more serious each year.

Chrysanthemum Stem Rot. — This disease has been known in Massachusetts only during the past two years, but has rapidly increased, and is considered by many growers as the most serious trouble threatening this important plant. It is characterized by a slow fading and withering of the leaves, beginning towards the bottom and gradually working up the stem. The flower develops poorly or not at all, and the whole plant finally dies prematurely. The cause of the disease is a fungus which grows in the stem and fills up the large ducts or vessels through which the water must pass in coming up from the roots. The development of this fungus has not yet been closely followed; but, since it is a species of *Fusarium*, similar forms of which cause like diseases in other plants, there can be but little doubt that the plant is first attacked from the soil, whence the fungus spreads into the stem and on up through it to a considerable height. As the pores become more and more clogged with the fungous growth, the water supply to the leaves is diminished, and consequently they gradually die and wither away. It is noticeable that this disease appears most commonly as a result of conditions favoring "damping off." Where young plants are crowded in flats or beds, those in the centre are generally the ones to show the trouble. This is likewise true with the other diseases of this class mentioned here, and such conditions should be avoided. The soil is to be looked upon as the chief source of infection in all such troubles. There is no danger of contagion in well-rooted plants by spores in the air, as with rusts, mildews and similar diseases. Healthy propagating stock, fresh soil, or that which has been sterilized,* and hygienic conditions, are the most effectual means of controlling such a trouble as this.

Carnation Stem Rot. — This disease has been longer and more generally known than that of the chrysanthemum, but

* One florist who grew 125,000 chrysanthemums sterilized the soil in ten houses, 200-300 feet long and 20-30 feet wide. Three and one-half houses, 300 feet long and 18-40 feet wide, in which carnations are growing, were also sterilized. The result of this experiment has not as yet been ascertained.

it is of comparatively recent occurrence. Most growers, however, know and fear it more than the rust or any other carnation disease. It has been found that there are in reality two distinct stem rots of the carnation, caused by two different fungi. In one a soft rotting of the whole stem occurs just at the surface of the ground, thus killing the plant quickly and completely. This is caused by the *Rhizoctonia* fungus described in our Bulletin No. 69 as the cause of a lettuce rot, and what is said there in regard to this destructive parasite applies equally well in the carnation disease. Since this fungus produces no spores to disseminate it in the air, but is limited to growth in the soil, sterilization by means of steam gives absolute results in preventing the disease, if healthy propagating stock is used. Another carnation stem rot is caused by a *Fusarium* similar to that in the chrysanthemum. In this case a soft, rapid decay does not occur, as in the *Rhizoctonia* disease, but the fungus works up through the pores of the stem, gradually clogging them, and the plant slowly fades away and dies. The stem goes to pieces in the last stages of the disease, but may be badly affected some time before this, the first symptoms appearing in the wilting of the plant. The use of healthy stock and fresh or sterilized soil is to be strongly urged where this disease has appeared, as well as the removal of all affected plants and the soil near them from the bed.

Aster Stem Rot. — A *Fusarium* stem rot of the China aster is very common and destructive, and seems to be on the increase. This disease will be more fully described in a bulletin of this division. Our investigations have shown that it is always first contracted as a "damping off" in the seed bed. Some plants die at this stage, but many live to be set out in the bed. Here the disease manifests itself at almost any time, by a gradual wilting, fading and death of the plant. Only in the last stages does the rotting of the stem appear; long before this the pores are clogged by the fungus, and wilting produced as in the other diseases. So far as our results go, it is possible to entirely avoid the trouble by starting the plants in the open ground, or otherwise avoiding "damping off" conditions. Thousands of plants

thus started have been grown on land badly infected with the disease, without a single case of stem rot. In this case, however, some other troubles with a similar effect must also be considered, particularly the attacks of root lice, one of the worst pests with asters. All of these will be fully discussed in the forthcoming bulletin.

The Present Status of Asparagus Rust in Massachusetts.

The asparagus rust made its appearance as usual in either one form or another during the summer and early fall. In July and August outbreaks of the uredo stage were perhaps not so severe, as a whole, as in some other years; nevertheless, it was severe enough to be likely to cause damage to the crop next year. The distribution of the rust in this State remains nearly the same as it has for some years, although within the last two years there has been a slight tendency for the uredo stage to show itself on some beds which heretofore have never presented anything but the teleuto spore stage. These beds appear to be in soil presenting more water retentivity than those soils upon which the rust has caused the most injury in years past. In this connection it should be stated that, while the uredo stage has shown on them, it does not occur nearly so early or so severely as on the lighter soils. The uredo spore stage occurred in the latter part of August on these beds. Other than these few instances, the distribution of the uredo spore stage, which constitutes that form of the rust causing practically the only injury, is about the same as it has been.

The rust constitutes a very serious factor to asparagus growers, especially to those who have a large number of acres located in infested regions. On account of the high prices of asparagus in the market last spring, the financial returns were not so unfavorable as they might have been, considering the small yield due to the effect of rust. The great difficulty that now exists with those growing asparagus on dry soils subject to rust infection is in starting new beds. The young beds rust so much earlier than the old ones that they suffer more severely as a consequence, and in many cases

are so weakened that it looks questionable whether they will ever develop into anything of value.

We have previously attempted to show that the outbreak of the uredo spore stage in this State bears a direct relationship to the water retentivity of the soil; that is to say, during a season of drought, soil capable of holding a small percentage of water becomes exceedingly dry, and it is on these soils that plants suffer. There has been nothing observed to disprove this idea, as we still find the uredo or injurious stage of the rust usually occurring on those soils which are light, and we do not get this stage on plants grown on other soils. We have made a great many additional analyses of soils of the State during the past two years, and the results obtained from such analyses bear out these conclusions. It is also noticeable that in those regions where the soil is lighter and more porous the uredo spore infection shows itself earliest each season, and where the soil is heavier and more compact infection is later, hence doing less damage. Beds situated in regions where the latter conditions prevail have not been damaged nearly so much in the last five years as those situated in the lighter and more porous soils.

The foundation of the idea of the relationship existing between the soil and the uredo outbreak is based upon vigor. In seasons of drought plants become very much weakened, hence they become infected; while those plants grown in neighboring towns, which are characterized by much heavier soil, never have anything but the teleuto spore stage occurring in September or October. The teleuto spore stage appears to be widely distributed in the State, and has been so from the very first. The question naturally arises, Why do these teleuto spore infected beds not have a summer stage? There are certainly plenty of beds which do not have it, and their distribution is wide. All the theories relating to the influence of such factors as dew, elevation, points of compass, shelter, utterly fail to account for a lack of uredo spore infection on these beds. The principal and most important difference found in these beds which are subject to the summer and fall infection is the one of soil texture and water-retaining capacity, which enables the plants,

other conditions being equal, to remain vigorous during seasons of drought. When the asparagus rust first made its appearance, there could be seen beds in which one portion was infected, while the other showed not the slightest trace of disease. The only differences existing in the plants were in their age and treatment. The differences of infection in these cases were due to different degrees of vigor. But such beds, being in regions where the soil is very sandy, subsequently became rusted. One bed on the college ground has had the fall stage since 1896, it usually appearing between September 15 and October 1. It has, however, never shown any trace of the rust in summer, or previous to September. Other beds, both young and old, situated close by, have been entirely free at times, and only insignificant teleuto spore pustules have been found on them very late in the fall. All the beds are situated on soils possessing high water-retaining properties, as well as an abundant supply of water from below.

Some attention was given to the rust problem by this division during the summer, and many localities have been examined. We have also, as usual, sent out a series of circulars, asking for information on certain points. Among other questions asked were those relating to the effect of dew, elevation and shelter from tree growths, etc., on infection. Not a single instance has been brought to our attention where the shelter produced by forest growths or crops has exerted any influence. As to the effect of elevation, considerable differences have always been observed by us in the amount of rust on a single bed, and such instances have been reported by asparagus growers in their correspondence. Where a bed runs down a little elevation, and where there are more moisture and organic matter contained in the soil, the plants are larger, more luxuriant, and there is less infection. No grower has been able to give us the slightest hint that plants are prone to show more infection in regions that are subject to dews. Since there is likely to be more dew deposited on the lower part of a bed than on the upper part of it, and if this factor is alone responsible for infection, we would expect to find more rust on those plants grown on the low portions of the bed than on the upper part. This is,

however, as we have stated, not borne out by our observations; on the other hand, the reverse is true. In general, elevation is connected with dew only in a relative sense, inasmuch as a location 300 feet above the sea may be subject to less dew than one 600 feet in height. And it is not to be presumed, as one writer has inferred, that the elevation above the sea level necessarily indicates in every instance the amount of dew which ought to be present there; in other words, local conditions affect the amount of dew. On Long Island it is reported that the lower beds rust first, and then those on higher elevations. It may be perfectly true that this takes place in that region and on those soils, although no such instance has come to our knowledge in this State. When plants are not resistant enough to stand uredo spore infection it is not difficult to understand how this might take place; but the presence of any amount of dew fails to infect some beds in this State. The principal bed on the college grounds is located near a pond, and only a few feet above it. If the effect of dew constitutes an important factor for uredo spore infection, then it would seem as if this bed ought to show it, but fortunately it never has.

There is evidence, however, that dew plays an important part in asparagus rust infection in those regions where all of the conditions are favorable for uredo spore outbreak; or, in other words, there are local conditions that exert an influence; but it appears to exert no such influence so far in those beds which show resistance enough to overcome the uredo stage. We have repeatedly seen plants grown under trees, or in any place where they were shaded by some covering, that scarcely showed the rust, whereas those plants just outside of the covering of the limbs, etc., might be badly affected. Our attention has been repeatedly called to this peculiarity by correspondence with asparagus growers, and this freedom from susceptibility in such local instances is undoubtedly caused by the absence of dew. These facts suggest a possible remedy for the rust, — at least in the starting of young plants. The young plants rust much more easily than the old ones; they are much more severely injured, and are a constant source of contamination. If

these can be started under cheese cloth covers, such as are now being so extensively used by tobacco growers in the Connecticut valley, it would certainly be an advantage to get such plants started before setting them out into permanent beds; and it would seem that the covering of cheese cloth would be as effectual as the tree covering in keeping off the dew, thus rendering them less susceptible to rust. Some asparagus growers have already considered this method of cultivation.

Experiments in spraying with the formula recommended by the Geneva station were tried during the past summer. This spraying was not done so often or so thoroughly as it could be done with the apparatus recommended for this work. At the close of the season the results of the applications were readily discernible, in the greener color and more vigorous shoots of the treated plants. This method is a costly one to apply, on account of its requiring a special apparatus and a fungicide which is difficult to prepare; thus asparagus growers do not take to it at present.

Fully as favorable results in one instance were obtained by the application of Paris green to a young bed. In this instance a large bed was treated twice for beetles during the summer. About August 18 the uredo stage of the rust commenced to show somewhat on the plants, and at this time one-half of the bed was treated with Paris green early in the morning, when the plants were covered with dew. This treatment seemed to arrest the outbreak of the rust to quite a remarkable extent. This method of treating is a very cheap one, as Paris green is not expensive, and the ease with which it can be put on makes the application far less expensive than by spraying with certain other fungicides. These plants were evidently treated just in the right time to be effective. From the results obtained, it would be worth while to give this method of treatment further trial. It is expected, however, that some experiments along other lines than those heretofore conducted will be tried next year, from which it is hoped that some results of importance will be obtained.

Sterilization of Soil in Greenhouses for Fungous Diseases.

This method of treating soil infected with disease-producing organisms or germs has been frequently dealt with in the publications of this division and elsewhere. We have recommended this method for the extermination of such fungous pests in the soil as cause the drop in lettuce and other plants, the timber rot in cucumbers, the *Rhizoctonia* and damping fungus (*Pythium De Baryanum*), and in part the stem rot in carnations. It has also been recommended for nematode worms, diseases caused by *Heterodera*, which affect indoor cucumbers, tomatoes, roses, violets, cyclamens, muskmelons and other greenhouse plants, and for the aphis and red spider. It is also effective in the destruction of weed seeds. One lettuce grower maintained that it paid to sterilize soil for this purpose alone. Heating of the soil greatly accelerates the growth of plants, and when this method of treatment is applied to lettuce houses affected with the drop and *Rhizoctonia*, it successfully eliminates these diseases, which are all a skilful grower needs concern himself about. This method of treatment has not been recommended for such diseases as top-burn, mildew of lettuce, nor for the damping fungus (*Botrytis*) in propagating pits, or for any other fungi giving rise to diseases which are freely disseminated by spores. Neither does this method, as ordinarily applied, succeed in accomplishing absolute sterilization of the soil. It is merely a sort of pasteurization. Cultures of the soil heated to 212° F. for a short time would show numerous bacteria, and myriads of others subsequently come in from the air and through the water applied to the soil.

The last year has seen quite remarkable strides made in the practice of methods of ridding the soil of parasitic organisms by means of heat. On account of the extensive use of the sterilization method on a large scale by the most efficient and practical gardeners, the process has been made very much cheaper, and hastened to a large degree. At the present time whole ranges of greenhouses owned by single

individuals, representing in some cases some acres, are now sterilized, and the method has been employed out of doors to some extent. Many of the houses treated are 300 or more feet in length and from 40 to 50 feet wide. Some market gardeners have practised sterilization of their houses for three years; not, however, for the sole purpose of ridding the soil of certain disease-producing organisms, as that could be accomplished by one treatment when properly done, but largely for the purpose of increasing their crops. A great many experiments have been made by this division during the last six years on various crops, in which the growth of plants in sterilized soil was compared with the growth of the same species of plants in precisely similar earth not sterilized. The effect of sterilization is quite marked in such experiments. W. W. Rawson, one of our largest lettuce growers in the State, who has observed the effect of sterilization on his own crops for two or three years, declared that he would rather have one inch of sterilized soil on his beds than any fertilizer which he had ever tried. For the purpose of determining, on a larger scale than we had heretofore shown, the effect heating the soil had upon the acceleration of a crop of lettuce, we made the following experiment in one of our houses: —

Two beds of nearly equal size were chosen, one of which was treated with hot water until the soil was soaked, and which showed an average temperature of 145° F. at the depth of 4 inches below the surface. The seed and prickers were also planted in boxes of earth which had been heated to 212° F. with steam. The other bed remained untreated, and likewise the soil in which the seed and prickers were started. Other than the hot water treatment given to the previously described bed, no perceptible difference existed. The number of plants in the treated bed was 308; the number in the untreated bed was 264. The results, however, were very marked, as shown below: —

Table showing Difference in Lettuce Plants grown in Sterilized and Unsterilized Soil.

	Plants in Untreated Soil.	Plants in Treated Soil.	Per Cent. of Gain.
Average weight of largest plants (grams), .	137.5	206.6	33
Average weight of typical plants (grams), .	56.2	86.3	33
Excess of water in treated plants over that of untreated.	-	-	2.2

The average weight of the largest plants represented that taken from four specimens selected from each bed in corresponding rows and close proximity. The four typical plants from each bed were selected at random, and they happen to show the same relative weight to each other as the largest ones do. The weights were all taken when the crop was four weeks along in the house and the treated ones were nearly ready for marketing. The plants were selected and weighed, and the amount of water determined in each lot, by Mr. A. L. Dacy, a student of the present senior class, who had charge of the house and who was quite familiar with the crop. The per cent. gain by starting the seed in sterilized soil and also transplanting the prickers in similarly treated soil, then transplanting into soil treated with hot water, was 33 per cent., which is a fair average increase due to this method of treatment.

The writer has made comparisons of lettuce plants grown in a rather poor quality of soil, one lot being sterilized and the other treated with the best possible combination of commercial fertilizers, with the result that the sterilized plants compare most favorably with those treated with fertilizers. This does not imply that sterilization will necessarily dispense with the use of fertilizers in the lettuce crop, if one wishes to apply them; as a matter of fact, however, they are seldom employed. The lettuce plant requires an exceedingly large amount of organic matter in the soil, and for this reason a generous supply of well-rotted horse manure is continually employed, for the double purpose of supplying organic matter and plant food. Plants

grown in sterilized soil are always lighter colored and more tender, and it is not a difficult task for an expert to pick out such plants in the market. Neither is it difficult to ascertain, from market specimens, to about what temperature lettuce plants have been subjected. In this respect the differences in plants are marked in a house where the soil has been treated twice as long in one place as in another. A gardener can readily pick out such places. It will be noticed in the table that there is 2.2 per cent. more water in the plants grown in the treated soil than in the untreated soil, and also that there is a corresponding decrease in the unburned residue which represents the organic matter, ash, constituents, etc. From the color and texture of lettuce grown in sterilized soil, this might be expected. The differences as shown in the above figures only represent one analysis.

The effect of sterilization on the soil is well illustrated in the case of a market gardener who picked 31,060 No. 1 cucumbers from 300 plants. The plants of this crop were carried through in treated soil from the beginning, *i.e.*, the seeds were sown in sterilized soil, and the various transplantings were made under similar treatment. The crop was grown after lettuce in the spring, when, it is true, cucumber vines bear heavily. Nevertheless, this was a phenomenal crop at any season of the year, and one which I have never seen equalled. Some allowance must be made in the size of this crop for the strain of cucumbers cultivated, which was a carefully selected stock of heavy bearers. Cucumber plants, nevertheless, respond quite remarkably to the influence of treated soil.

A number of methods of treating soil with heat have been employed by practical greenhouse men, and many experiments on different methods have been made by this division during the last few years. We have been able to observe the efficiency and practical utility of these various methods, and have reported on them at different times. The method of treating the soil by steam to the distance of one foot or more in depth has always appeared to us as the best one to be employed, and, since the cost of such treatment has been

greatly reduced of late, there appears to be no longer any reason why it can not be extensively used to eradicate diseases in those cases where there seems to be urgent need. The cost of treatment in badly infested houses proves an excellent financial investment. For example, some houses have had the drop in them to such an extent that 50 per cent. of the plants would succumb, and in some rare cases the whole crop has been lost. In a house containing 4,000 dozen plants at 50* cents per dozen the value of the crop would be $2,000; or, at 25 cents per dozen, $1,000. A loss of 50 per cent. would reduce the value of the crop to $1,000 and $500 respectively. Such a loss is the more provoking, inasmuch as the maximum amount of the drop occurs just about the time when the plants are mature, and all the labor bestowed on the crop in transplanting, the care given to the same, amount of heat utilized and valuable space which they have taken up, are all for nothing.

A house of this description was sterilized during the past winter at a cost of $100, and in examining this crop, which was one of the most perfect we have ever seen, there was only one case of disease in the whole house. This one diseased plant occurred near an iron post that supported the house, and there was evidently a small portion of soil in that spot which had not been sufficiently treated. The cost of treating this small neglected area would, however, have been very insignificant. When we observed the crop, it had already been mature for nearly two weeks, and was being held back for a better market, which gave an excellent opportunity for any further drop to develop, if the germs were present. There appears to be no reason why, if a house is once treated as thoroughly as this house was, another treatment should be required for some years, providing care is taken to prevent contamination from old refuse material which contains the drop fungus. By allowing a few contaminated areas to exist in the soil, as a result of imperfect treatment, it would probably be from three to five years before the loss would reach that amount when it would be

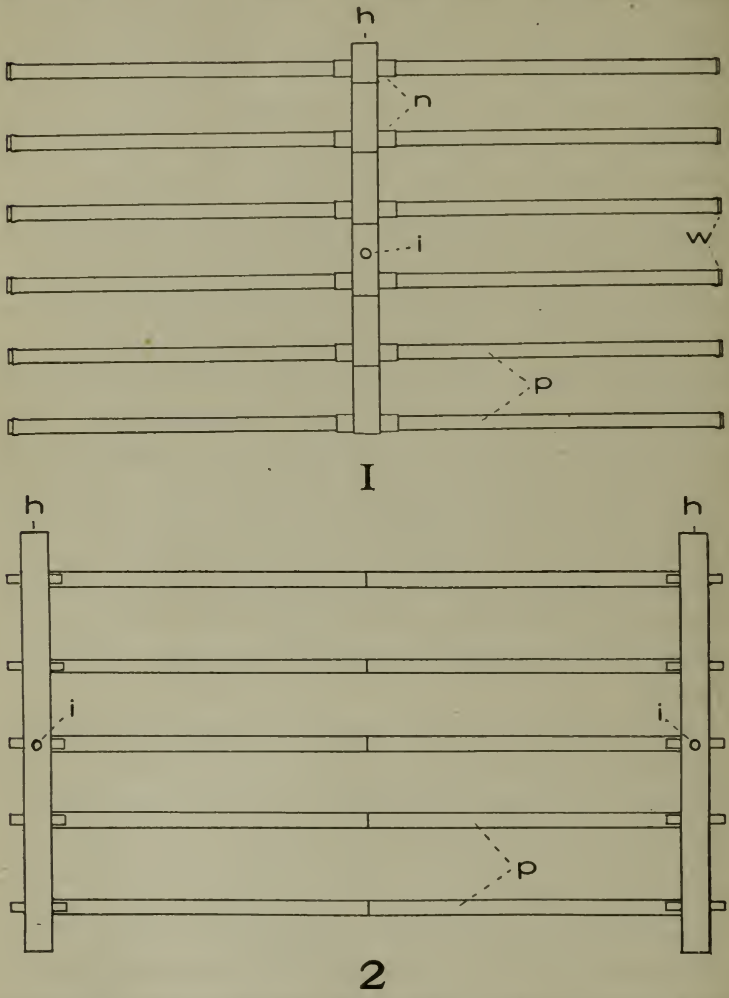
* At the present time, December, 1901, a neighboring market gardener is disposing of his lettuce at 65 cents per dozen.

necessary to treat the soil again. It requires no argument to show that the expense of $100 for treatment of the house that would be worth $2,000 at 50 cents per dozen, or even $1,000 at 25 cents per dozen, is a good investment, even if the treatment has to be repeated each year. On the basis of a five-year treatment, which is, in our own estimation, all that is required, the gain is nearly five times as great. The increased value to the soil resulting from such treatment, and the possibility of having less weeds and fewer aphis, should also be taken into consideration in estimating the benefits derived from the use of this method. The oldest, most conservative and intelligent lettuce growers were enthusiastic over the results of this experiment.

Methods of Sterilizing. — The methods employed for heating the soil have been by either hot water or steam, with some variation in the mode of applying the latter. Messrs. Hittenger Bros. of Belmont have made extensive use of the hot-water method, and their later constructed houses have special facilities for applying this in the most economic manner. The hot-water method requires the treatment of the soil previous to the putting in of each crop, and only a few inches of the surface soil are sufficiently heated by this practice to kill the mycelium of the drop fungus.

The heating by steam is now done largely by the aid of perforated pipe, and in some cases use is made of 2 inch porous tile, though this method is not so applicable. If finely perforated tiles could be obtained in the market at a reasonable cost, their use would be much more valuable for this purpose than at present. The various contrivances are made out of perforated pipe, varying from 1 inch to 3 inches in diameter, usually placed from 7 to 12 inches apart, and made up into frames from 10 to 20 feet or more in length and into any desired width. The size and number of the perforations vary much in different appliances. When they are rather large (¼ inch in diameter) they are frequently covered with burlap. In some appliances the perforations are ¼ inch in diameter and are only 1½ inches apart each way. In others the perforations may be only ⅛ inch in

diameter and from 3 to 6 inches apart, with two or three rows of such holes extending around the circumference of the pipe. Some of these appliances are not made up into



FIGS. 1 AND 2. — Showing types of sterilization apparatus : *h*, header; *n*, nipple; *w*, wooden plug; *i*, steam inlet; *p*, pipes. Both appliances are 20 feet long and about 8 feet wide.

permanent frames, but are in sections, easily put together or taken apart, and so constructed that they can be readily extended into any length or width desired. These frames are provided with headers placed transversely, which are pipes of larger diameter, containing perforations, and nipples are

inserted at intervals which readily fit into the extension pipes (see Figs. 1 and 2). In some instances the headers are placed at each end, thus forming with the extension pipes a frame composed of a series of rectangles (Fig. 2). In this form a complete circulation of the steam can take place. In others the headers are in the middle, and the extension pipes lead off in opposite directions (Fig. 1). In the latter case the ends of the extension pipe are plugged with wood, and a complete circulation of steam does not occur. The material most frequently used is iron pipe. The form devised by Mr. Cartter is constructed out of perforated galvanized-iron tubes, and is very light and easy to handle.

The method generally adopted by lettuce growers in heating their soils is to place the apparatus on the surface of the bed. If the bed is 20 feet wide, then it will be most convenient to have the heating appliance about 10 feet wide and 20 to 30 feet long. This is placed midway between the edges of the bed, and the soil to the depth of 1 foot is dug out on either side of the appliance and thrown on top of it.

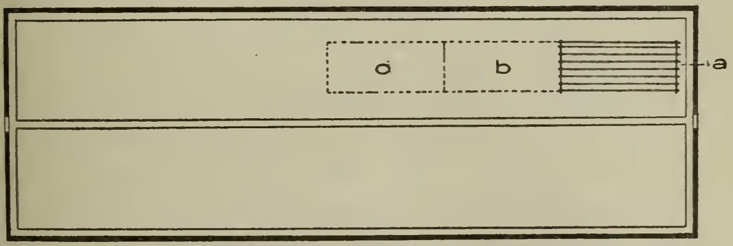


Fig. 3.—Plan of house, showing methods of sterilization: *b*, *c*, successive positions of the apparatus.

This covers the heating apparatus to a depth of 1 foot. The steam is now turned on and the soil heated. After sufficient steaming has taken place, the pipes can be pulled out and set up ready for the next treatment (see Fig. 3). The soil previously treated should be covered up with some old canvas, if available, or, in fact, with anything that will retain the heat, and allowed to stand some hours, after which the top portion is shovelled back to where it was taken from. Not only is the 1 foot of top soil heated by

this method, but the soil under which the apparatus rests is equally well done, provided too much haste is not made in removing the treated soil. In one case that was examined, where the steam was left on for one and one-half hours late in the afternoon, and the top coat of soil not disturbed until the next morning, we obtained the following records of soil temperatures at noon on the following day, or nineteen hours after the steam was applied and five hours after the top soil and apparatus had been removed: temperature of soil 2 feet below the surface, 120° F.; temperature of soil 1 foot below the surface, 175° F. Two masses of top soil were heated in this instance during the one and one-half hours, the last one being left on over night. The average pressure of steam applied was only 13 pounds. It always astonishes those who heat soil for the first time to find that steam can penetrate such a distance below the surface in so brief a period. In this particular case the steam was oozing out of the soil 30 inches below the surface, no examination below this depth being made. The most efficient appliances for sterilization are those based upon our recommendations in former publications. A 2 inch pipe is superior to a 1 inch, 1¼ inch or 1½ inch pipe. A high pressure of steam is more effectual than a low pressure, and the larger the number of perforations in the pipe, the more widely and evenly is the steam disseminated and the more quickly and cheaply can the soil be heated. The area of a series of small holes placed uniformly in a given length of pipe would undoubtedly be more effectual than the same area of larger holes in the same length of pipe. In the latter case the holes would be further apart, and allow larger volumes of steam to escape; in the former case they would be nearer together, and would be capable of heating the soil more evenly and in our opinion more effectually. In our judgment, holes ⅛ inch in diameter, when placed near together, would be sufficient for the exit of steam, and the soil would be less likely to go through them than through holes ¼ inch in diameter.

In proportion as the appliances have been improved for sterilizing soils, the cost of the operation has been greatly reduced. From reliable estimates which we have been able

to obtain from practical lettuce growers and others who have heated their soil, the cost, including coal, labor, etc., but not the cost of the tile or apparatus used, is as follows: —

In a house 225 feet long by 20 feet wide, one-third of which was heated at a time by steam passing through 2 inch tile placed 8 inches below the surface and 1 foot apart, and forming a continuous circuit, the cost was at the rate of $16 per 1,000 cubic feet, where the pressure of steam used varied from 30 to 80 pounds. This house had been previously sterilized by the same method, excepting that the tiles were placed 18 inches apart, instead of 1 foot, with less favorable results. The heating was continued day and night, as this could be easily done, on account of a night foreman being employed. The estimated cost of removing the soil from a house to the depth of 1 foot, which was actually done in a similar house a few years ago, and placing in new soil without carting the same, was at the rate of $37.50 per 1,000 cubic feet.

Another house, 40 feet wide by 300 feet long, was treated by a lettuce grower with an average pressure of 30 pounds of steam passed through 1 inch iron pipes, furnished with a series of perforations 6 inches apart and 3/16 inches in diameter. These pipes were made up into a frame, 7 inches distant from one another. The estimated cost of sterilizing 1,000 cubic feet of soil, based upon the treatment of the whole house, was $8.33.

A lettuce grower who has a range of houses each about 300 feet long by 36 feet wide has recently treated them all by steam. A boiler house, situated at the most convenient place on the establishment, was constructed, and a new forty horse-power boiler was placed in it, to be used exclusively for the purpose of sterilization. The sterilizing apparatus consisted of a series of 3 inch T's, furnished with 2 inch nipples, which was placed in the centre of the apparatus, thus forming a header. From these nipples there extended in each direction a series of perforated 2 inch iron pipes which were 10 feet in length (see Fig. 2). This made the apparatus when complete about 20 feet long and 8 feet wide. The apparatus was placed on the surface of the soil, the ends of the pipe stopped up with wooden plugs, and the earth

from each side to the depth of 1 foot or more was placed upon it. The cost of this appliance was about $20, though Mr. C. R. Learned, who devised it, thinks that he could make a duplicate of it for about $17. It took three days to treat a house 300 feet long and 36 feet wide, and, from the estimated cost of labor, fuel, etc., the treatment was made at the rate of $5.92 per 1,000 cubic feet. This work was done in the summer, when labor was probably more expensive than it would be in winter. Mr. Learned informs me that he expects better results the next time.

A sterilizing machine used by Mr. Cartter is made of 2 inch galvanized-iron tubing, of 20 ply, with 3/16 or 1/4 inch holes, 1 inch apart each way. The headers are 2 to 3 feet long and 3 inches in diameter, and are made up of the same material and perforated in like manner. Galvanized-iron nipples are soldered on both sides of the headers, 8 inches apart. The ends of the 10-foot length pipes are made to fit on to the nipples and also into one another, so that any desired length or width of appliance can be obtained (Fig. 1). This apparatus contains more perforations to the linear foot than any we have seen, and for this reason, and owing to the diameter of the tubing used, it is the most effectual as a heater. We observed one test with this apparatus in which 400 cubic feet of soil were treated at the rate of $2 per 1,000 cubic feet. This includes the cost of labor at 10 cents per hour, which was required to place the apparatus in position and cover it with soil ready for use, and replace the same when heated; also the amount of fuel burned during the treatment, together with the amount of coal it required to bring the same amount of water in the boiler to the same degree of temperature, and the steam to the same pressure as before the treatment was started. Whether this rate of sterilization by the use of this apparatus is actually attained when applied on a large scale, we have not learned.

When soil can be sterilized at $2 per 1,000 cubic feet, or even at $5, there is no longer any question concerning the practical application of this method to rid greenhouses of some of its worst enemies, which interfere with the produc-

tion of healthy and profitable crops. Even when the cumbersome tile method is employed, the cost of sterilization is less than one-half the cost of removing the old soil from a house and supplying it with new. So universal is this method of treating greenhouses devoted to lettuce, cucumbers, and in some cases to those devoted to violets, carnations, chrysanthemums and roses, that we are unable to give at the present time the number of acres which have been and are being treated. The method, we are told, is to be tried on onions next season grown out of doors. It has already been utilized in the culture of out-door lettuce and celery to a small extent, and tobacco growers are beginning to use sterilized soil in which to start their seedlings. We understand that it costs $65 to weed an onion bed of one acre in extent. It remains to be seen whether the weeds can be eliminated by the use of steam for a less price, to make it an object to use it. Such a treatment would certainly be of great value in the control of smut.

It is not the object of this division to recommend this method too enthusiastically or as a cure for all difficulties. On the other hand, we are desirous of seeing the method tried wherever there is reasonable possibility of its success. In the mean time, we prefer to see the method developed as it is now being done, by practical men who have to reckon with the question of dollars and cents, for, after all, they are the ones who must render the final judgment on any process of treatment. Our facilities have not been sufficient to test this sterilization method on a large scale, neither are we confronted with the economic conditions which commercial men have. For these reasons we have drawn quite extensively on the results obtained by practical men, who apply the method on a large basis, rather than on our own experiments, in discussing this subject at this time.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

The work of the entomological division of the experiment station during the past year has followed the lines of previous reports. The amount of correspondence has been much larger than ever before, being due in a great measure to the appearance of the elm-leaf beetle in the eastern portion of the State in such numbers as to do great damage, and also as an indirect result of the appointment of tree wardens. These officials in the course of their duties have watched the trees and the insects upon them closely, and have frequently communicated with the station concerning their observations. Correspondence of this kind has increased nearly ten per cent. over that of former years, which is of itself a testimonial of the value and success of the tree warden law.

The entire edition of a former publication of the station upon the elm-leaf beetle having become exhausted, a new bulletin on this insect was prepared and published during the summer. This was the only paper from the entomological division published by the station, but others were prepared by the division and published during the year by the secretary of the Board of Agriculture of Massachusetts. The most important of these was a paper on "Three common orchard scales," with figures and half-tones, published in the Crop Report for May, 1901, and which has been in much demand.

The station was represented at the meeting of the Official Horticultural Inspectors of the United States, held at Washington, Nov. 11–13, 1901. At this meeting much uniformity of practice among the nursery inspectors of the different States was established and many results of value obtained.

Nursery inspection for Massachusetts is one of the duties of the entomological division of the station, and requires a total of two or three weeks' time each year. The results of this work are of direct value to the nurserymen only, but in an indirect way lead not only to a more careful watch of the nurseries by their owners, but to the utilization of the facilities of the experiment station as a place of inquiry and reference on subjects connected with insects and plant disease, thus bringing the station into touch with an occupation where its services are of great value.

Insects of the Year.

The year has not been marked by the unusual abundance of any particular insect, except, perhaps, the elm-leaf beetle in the eastern part of the State. This insect has been injuriously abundant in the Connecticut valley for a number of years, but has failed to make its presence felt in the more eastern cities and towns until recently. During the past summer, however, it has made havoc with the foliage of the elms in hundreds of places, and caused a large amount of correspondence with this division, while much of what has been published in the newspapers concerning this insect consisted of remedies and methods of treatment which were inefficient or utterly worthless.

The brown-tail moth has increased in abundance, and in the area which it occupies, until it is probably present in more than twelve hundred square miles in this State, and has extended into Maine and New Hampshire. While in some ways it is an easy insect to control, the assurance that no concerted action will ever be taken by all those persons on whose trees it is present renders it certain that it will remain an important pest; while the serious nature of the irritation caused by the spines of the caterpillars when they touch man has already been a source of much discomfort in the localities where it is most abundant.

The gypsy moth has reappeared at those points in the State where the work of the gypsy moth committee was unfinished when its functions were ended two years ago. It is but a question of time when the area from which it had then been exterminated will become reinfested. The entire

responsibility for this unfortunate state of affairs rests upon the Legislature, which discontinued the work of the commission, thereby deliberately wasting all the money previously expended.

The birch *Bucculatrix* has been in evidence during the past year, but, as was predicted in last year's report, has been most abundant in the northern and eastern portions of the State, where little had been seen of it before.

The San José scale has spread rapidly during the year, and is now known to occur in fifty-two localities in Massachusetts. It is not only present in nurseries and orchards, but in several instances it is generally present over areas of several miles. In one place — a residential suburb — nearly every deciduous tree and shrub within an area of five square miles is infested, and many of the plants are already dead, while others are dying. During the summer the scale was found generally distributed through the orchard of the Massachusetts Agricultural College, which consists of over a thousand trees. The origin, distribution and present conditions in this case have been carefully studied, and a special report on the subject has been transmitted to the trustees.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The work of the meteorological division during the past year has been confined almost entirely to the observation of the various weather phenomena, the tabulation of the data obtained and the computation of the daily and monthly means of the several weather elements. The records of each month are compared with the normals of the ten-year period, 1889–99, and the more important departures from mean conditions obtained.

At the beginning of each month a summary of the weather of the preceding month has been prepared and published as a four-page bulletin. On the inside pages are given a number of the daily means, some of the more important maxima and minima daily records, together with data of the winds and amount of precipitation. On the outside pages a summary of the various weather elements with the monthly means is given, as well as general remarks on the weather for the month. The usual annual summary will be prepared and published with the December bulletin.

The local forecasts for the weather for the following day have been furnished daily, except Sunday, by the New England section of the United States Weather Bureau. In accordance with these predictions, the proper weather flags have been displayed from the flag staff on the tower. At the request of the section director, the weekly snow reports are being sent to the Boston office this season, as heretofore.

Owing to the failure during the past few years to get satisfactory results with our electrical apparatus for the determination of soil moisture, these observations were discontinued this year. This work will be resumed whenever more improved apparatus can be obtained.

The monthly observations of the declination of the magnetic needle, begun last year, have been continued. The results obtained the latter part of the year have not been very satisfactory, probably due to local attraction caused by the line of steam pipe to the drill hall. By changing the true meridian to another location it is expected to remedy this.

No new equipment has been added during the year, but a three years' supply of charts for the Draper instruments has recently been purchased.

At the opening of the college, in September, Mr. C. L. Rice, the observer, retired from the division, and was succeeded by the assistant observer, Mr. H. L. Bodfish.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, SAMUEL W. WILEY, JAMES E. HALLIGAN.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1901.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 61; of these, 37 have offices for the general distribution of their goods in Massachusetts, 8 in New York, 7 in Connecticut, 3 in Vermont, 1 in Rhode Island, 2 in Canada, 1 in New Jersey and 1 in Maryland.

Two hundred and sixty-six brands of fertilizer, including chemicals, have been licensed in the State during the year.

Four hundred and forty-nine samples of fertilizers have thus far been collected in the general markets by experienced assistants in the station.

Three hundred and seventy-one samples were analyzed at the close of November, 1901, representing 230 distinct brands of fertilizer. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 75, July; and No. 77, November, 1901.

As in previous years, the samples of licensed fertilizers which have not been already analyzed, together with other samples that may be collected, will be analyzed for publication in our March bulletin, 1902. (This includes several samples forwarded by manufacturers at the inspector's request, which were not found in the general markets by our collectors. All such samples are certified by the manufacturers as being an impartial representative of the brands in question.)

For the readers' benefit, the following abstract of the results of our analysis is here inserted: —

	1900.	1901.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	15	7
Number with two elements above the highest guarantee,	24	15
Number with one element above the highest guarantee,	85	51
Number with three elements between the lowest and highest guarantee,	118	142
Number with two elements between the lowest and highest guarantee,	92	91
Number with one element between the lowest and highest guarantee,	43	39
Number with three elements below the lowest guarantee,	1	-
Number with two elements below the lowest guarantee,	11	8
Number with one element below the lowest guarantee,	50	86
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	5	7
Number with one element above the highest guarantee,	20	12
Number with two elements between the lowest and highest guarantee,	19	24
Number with one element between the lowest and highest guarantee,	6	14
Number with two elements below the lowest guarantee,	-	2
Number with one element below the lowest guarantee,	20	14
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	15	7
Number between lowest and highest guarantee,	9	18
Number below lowest guarantee,	10	9

A comparison of the above-stated results of our inspection with the results of the previous year shows that the manufacturer's standard or guarantee has been as well maintained as in the past; and in nearly all cases where a discrepancy has occurred between the results of analysis and the manufacturer's guarantee, the commercial value of the article has not suffered, the low percentage of one element of plant food having been balanced by a correspondingly high percentage of some one of the other ingredients.

The fertilizer bulletins become of the utmost value when considered from the stand-point of a source of intelligence to the farmer to select his fertilizer for the next year's consumption.

In deciding what brands of commercial fertilizer to purchase for general use, select the one that will furnish the greatest amount of nitrogen, potash and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1900 and 1901 (Cents per Pound).

	1900.	1901.
Nitrogen in ammonia salts,	17.00	16.50
Nitrogen in nitrates,	13.50	14.00
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers.	15.50	16.00
Organic nitrogen in fine bone and tankage,	15.50	16.00
Organic nitrogen in medium bone and tankage,	11.00	12.00
Phosphoric acid soluble in water,	4.50	5.00
Phosphoric acid soluble in ammonium citrate,	4.00	4.50
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

A comparison of the above trade values for 1900 and 1901 shows a somewhat higher cost of organic nitrogen and nitrogen in form of nitrates, and a corresponding decrease in the cost of ammonia salts. Phosphoric acid soluble in water

was given a half cent higher valuation than in the previous year.

The above trade values are, as in years past, based on the market cost, during the six months preceding March, 1901, of standard raw materials which enter largely into the manufacture of commercial fertilizers found in our markets. The following is a partial list of such materials : —

Sulfate of ammonia.	Dissolved bones.
Azotine.	Acid phosphate.
Cotton-seed meal.	Refuse bone-black.
Linseed meal.	Ground phosphate rock.
Bone and tankage.	High-grade sulfate of potash.
Nitrate of soda.	Sulfate of potash and magnesia.
Dried blood.	Muriate of potash.
Castor pomace.	Kainit.
Dry ground fish.	Sylvinite.
Dry ground meat.	Crude saltpetre.

In order to use the table of trade values in calculating the approximate value of a fertilizer, calculate the value of each of the three essential elements of plant food — nitrogen, phosphoric acid and potassium oxide (including the different forms of each wherever different forms are recognized in the table) — in one hundred pounds of the fertilizer, and multiply each product by twenty, to raise it to a ton basis. The sum of these values will give the total value of the fertilizer per ton at the principal places of distribution. An example will suffice to show how this calculation is made : —

Analysis of Fertilizer (Per Cent., or Pounds in One Hundred Pounds of Fertilizer).

Nitrogen,	4
Soluble phosphoric acid,	8
Reverted phosphoric acid,	4
Insoluble phosphoric acid,	2
Potassium oxide (as sulfate),	10

	Value per Hundred Pounds.	Value per Ton (Two Thousand Pounds).
Four pounds nitrogen, at 16 cents,	$0 64×20	=$12 80
Eight pounds soluble phosphoric acid, at 5 cents,	40×20	= 8 00
Four pounds reverted phosphoric acid, at 4.5 cents,	18×20	= 3 60
Two pounds insoluble phosphoric acid, at 2 cents,	04×20	= 80
Ten pounds potassium oxide, at 5 cents,	50×20	= 10 00
Value per ton,	. . . . .	$35 20

Table A gives the average analysis of officially collected fertilizers for 1901. Table B gives a compilation of analyses of commercial fertilizers for the year 1901, showing the maximum, minimum and average percentages of the different essential elements of plant food found in special crop fertilizers, so called.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1901.*

Nature of Material.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							Total.		Available.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	10.94	2.77	2.52	4.72	3.35	2.87	10.94	9.48	8.07	6.30	5.21	4.91
Ground bones,	6.58	2.80	2.28	-	10.54	14.69	25.23	24.21	10.54	7.96	-	-
Tankage,	7.01	4.69	4.18	1.47	7.27	9.72	18.46	17.33	8.74	8.35	-	-
Dry ground fish,	8.74	8.51	8.14	-	4.09	6.73	10.82	9.00	4.09	-	-	-
Dissolved bone-black,	12.01	-	-	12.99	2.96	1.50	17.45	16.33	15.95	15.00	-	-
Acid phosphate,	7.41	-	-	7.30	4.72	1.82	13.84	13.50	12.02	12.00	-	-
Wood ashes,	12.39	-	-	-	-	-	1.62	1.25	-	-	5.70	4.75
Cotton-hull ashes,	2.10	-	-	-	-	-	8.76	8.00	-	-	30.12	20.00
Castor pomace,	7.69	4.98	4.74	-	-	-	-	-	-	-	-	-
Cotton-seed meal,	5.88	6.82	7.00	-	-	-	-	-	-	-	-	-
Dried blood,	8.12	9.77	9.12	-	-	-	-	-	-	-	-	-
Nitrate of soda,	1.46	15.75	15.43	-	-	-	-	-	-	-	-	-
Muriate of potash,	1.79	-	-	-	-	-	-	-	-	-	49.39	50.01
Sulfate of potash and magnesia,	4.08	-	-	-	-	-	-	-	-	-	24.70	25.50
High-grade sulfate of potash,	.54	-	-	-	-	-	-	-	-	-	48.64	48.17

TABLE B. — *Compilation of Analyses of Commercial Fertilizers for the Year 1901.*

Name of Fertilizer.	Analyses.	Moisture.	Nitrogen in One Hundred Pounds.			Total Phosphoric Acid in One Hundred Pounds.			Available Phosphoric Acid in One Hundred Pounds.			Potassium Oxide in One Hundred Pounds.		
			Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer, ...	17	11.52	5.11	1.00	2.59	14.51	9.62	11.53	9.67	5.40	8.23	9.94	1.72	4.02
Fruit and vine fertilizer, ...	4	8.11	3.24	2.06	2.38	13.64	8.11	10.89	8.98	4.63	6.76	10.52	5.14	7.40
Grain fertilizer, ...	13	10.00	9.09	1.19	3.44	17.99	6.17	12.18	11.28	4.74	8.65	13.62	2.16	5.73
Grass fertilizer, ...	15	8.77	5.47	1.19	3.80	17.99	6.17	10.45	10.75	5.07	7.05	13.62	2.22	5.47
Market-garden fertilizer, ...	16	10.82	4.85	.97	3.15	13.33	6.17	10.38	10.90	5.07	8.06	11.42	2.33	6.27
Potato fertilizer, ...	39	11.03	5.44	1.22	2.63	13.74	7.37	10.73	10.80	4.00	8.03	10.00	2.30	5.68
Tobacco fertilizer, ...	10	8.84	6.36	1.16	4.07	13.25	4.35	9.21	11.41	3.48	7.27	17.70	3.34	8.62

From the great variations in the results of analyses of the above special crop fertilizers (see Table B) it will be readily observed that it will be unsafe to be guided by trade names wholly when selecting fertilizers for the growing of special crops.

Local conditions as to the character of the soil and subsoil, the previous management of the soil and the system of crop rotation employed should all enter into consideration when selecting a fertilizer. A study of the soil should be made, to find in what direction the plant food has become depleted; and when these facts have become established, then supply the wants of the soil in the most suitable and economical manner. When the character of a soil is not known and its wants are not manifested, it is advisable to use a fertilizer more nearly corresponding to what a chemical analysis of the crop shows is required for its proper development.

An example is here inserted for the purpose of illustrating how the chemical composition of a crop may serve as a guide in the compounding of a commercial fertilizer, also to serve as an object lesson of how to intelligently use the compilation of analyses which is a part of the annual report of the chemical department for this year. We will take the average composition of cranberries, as this appears first in our table of compilation of fruits, etc.: —

Average Analysis of Cranberries.

	Parts per Thousand.
Phosphoric acid,	.30
Potassium oxide,	1.00
Nitrogen,	.80

The relative proportion of phosphoric acid, potassium oxide and nitrogen present, according to this analysis, is: —

Phosphoric acid,	1.00
Potassium oxide,	3.33
Nitrogen,	2.66

In other words, for every pound of phosphoric acid removed from the soil by a crop of cranberries, there are 3.33 pounds of potassium oxide and 2.66 pounds of nitrogen re-

moved. A fertilizer supplying the essential elements of plant food in this proportion would, therefore, under the above-stated conditions, be more suitable to use.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1901, to May 1, 1902), and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- Nitrate of Soda.
- Muriate of Potash.
- High-grade Sulfate of Potash.
- Double Manure Salt.
- Dry Ground Fish.
- Fine-ground Bone.
- Dissolved Bone-black.
- Plain Superphosphate.
- Dry Blood.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Bradley's X. L. Superphosphate.
- Bradley's Potato Manure.
- Bradley's Potato Fertilizer.
- Bradley's Complete Manure for Potatoes and Vegetables.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's English Lawn Fertilizer.
- Bradley's Complete Manure with Ten Per Cent. Potash.
- Bradley's Complete Manure for Corn and Grain.
- Bradley's Complete Manure for Top-dressing.
- Bradley's Grass and Lawn Top-dressing.
- Breck's Lawn and Garden Dressing.
- Brightman's Fish and Potash.
- Church's Fish and Potash.
- Grass and Grain.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
- Clark's Cove Bay State Fertilizer.
- Clark's Cove Bay State Fertilizer, G. G.
- Clark's Cove Potato Manure.
- Clark's Cove Potato Fertilizer.
- Clark's Cove Great Planet Manure.
- Clark's Cove King Philip Guano.
- Clark's Cove Grass Fertilizer.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's Corn Phosphate.
- Crocker's New Rival Phosphate.
- Crocker's General Crop Phosphate.
- Crocker's A. A. Complete Manure.

The American Agricultural Chemical Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.: —
- Blood, Bone and Potash.
- Potato and Root Crop Manure.
- Complete Ten Per Cent. Manure.
- Potato Manure.
- Farm Favorite.
- Animal Fertilizer.

The American Agricultural Chemical Co. (East India Chemical Works, branch), New York, N. Y.: —
- East India Chemical Works' Complete Potato Manure.
- East India Chemical Works' A. A. Phosphate.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.: —
- Northern Corn Special.
- Grass and Oats Fertilizer.
- General Fertilizer.
- Garden Special.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.: —
- Pacific High-grade General.
- Pacific Soluble Pacific Guano.
- Pacific Potato Special.
- Pacific Nobsque Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.: —
- Animal Corn Fertilizer.
- Potato Manure.
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Corn Manure.
- Quinnipiac Market-garden Manure.
- Quinnipiac Grass Fertilizer.
- Quinnipiac Havanna Tobacco Fertilizer.
- Quinnipiac Climax Phosphate.
- Quinnipiac Potato Phosphate.
- Quinnipiac Special with Ten Per Cent. Potash.

The American Agricultural Chemical Co. (Read Fertilizer Co., branch), New York, N. Y.: —
- Read's Farmers' Friend.
- Read's Practical Potato Special.
- Read's Bone, Fish and Potash.
- Read's Vegetable and Vine.
- Read's High-grade Farmers' Friend.
- Read's Standard.

The American Agricultural Chemical Co. (Standard Fertilizer Co., branch), Boston, Mass.: —
- Standard Fertilizer.
- Standard Guano.
- Standard Complete Manure.
- Standard Special for Potatoes.

The American Agricultural Chemical Co. (Henry F. Tucker, branch), Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Potato Fertilizer.
- Tucker's Imperial Bone Superphosphate.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
- Williams & Clark's High-grade Special.
- Williams & Clark's Americus Phosphate.

The American Agricultural Chemical Co. — *Con.*
- Williams & Clark's Potato Phosphate.
- Williams & Clark's Corn Phosphate.
- Williams & Clark's Potato Manure.
- Williams & Clark's Royal Bone Phosphate.
- Williams & Clark's Prolific Crop Producer.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.: —
- Corn Fertilizer.
- Potato Manure.
- Superior Truck Fertilizer.
- Bermuda Onion Grower.
- Grass and Oats Fertilizer.

Wm. H. Abbott, Holyoke, Mass.: —
- Animal Fertilizer.
- Eagle Brand.
- Tobacco Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-seed Hull Ashes.

Armour Fertilizer Works, Baltimore, Md.: —
- Blood, Bone and Potash.
- Ammoniated Bone with Potash.
- Grain Grower.
- All Soluble.
- High-grade Potato.
- Bone Meal.

H. J. Baker & Bro., New York, N. Y.: —
- Castor Pomace.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.

Bartlett & Holmes, Springfield, Mass.: —
- Animal Fertilizer.
- Pure Ground Bone.
- Tankage.

Berkshire Fertilizer Company, Bridgeport, Conn.: —
- Berkshire Complete Fertilizer.
- Berkshire Ammoniated Bone Phosphate.
- Berkshire Potato Phosphate.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Market Garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Fertilizer.
- Bowker's Fish and Potash, "Square Brand."
- Bowker's Potato Phosphate.
- Bowker's Sure Crop Phosphate.
- Bowker's Market-garden Manure.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Tobacco Starter.
- Bowker's Potash or Staple Phosphate.
- Bowker's Ammoniated Dissolved Bone.
- Bowker's Superphosphate.
- Bowker's Ground Bone.
- Gloucester Fish and Potash.
- Dissolved Bone-black.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash-magnesia.
- Sulfate of Potash.
- Dried Blood.
- Tankage.
- Wood Ashes.

Butchers' Rendering Co., Fall River, Mass.: —
- Tankage.

E. Frank Coe Co., New York, N. Y.: —
- E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
- E. Frank Coe's Gold Brand Excelsior Guano.
- E. Frank Coe's Tobacco and Onion Fertilizer.
- E. Frank Coe's Bay State Phosphate
- E. Frank Coe's F.P. Fish and Potash.
- American Farmers'. Market-garden Special.
- American Farmers' Complete Potato.
- American Farmers' Corn King.
- Farmers' Grass and Grain Fertilizer.
- Nitrate of Soda.

John C. Dow & Co., Boston, Mass.: —
- Dow's Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Imperial Liquid Plant Food.
- Imperial Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
- Canada Unleached Hard-wood Ashes.

Thomas Hersom & Co., New Bedford, Mass.: —
- Meat and Bone.
- Ground Bone.

F. E. Hancock, Walkerton, Ontario, Can.: —
- Pure Canada Unleached Hard-wood Ashes.

C. W. Hastings, Cambridgeport, Mass.: —
- Ferti Flora.

John Joynt, Lucknow, Can.: —
- Canada Hard-wood Ashes.

Thomas Kirley & Co.'s Fertilizer Works, South Hadley Falls, Mass.: —
- Pride of the Valley.

Lister's Agricultural Chemical Works, Newark, N. J.: —
- Lister's Success Fertilizer.
- Lister's Special Corn and Potato Fertilizer.
- Lister's High-grade Special for Spring Crops.
- Lister's Animal Bone and Potash.

Lowe Bros. & Co., Fitchburg, Mass.: —
- Tankage.

Lowell Fertilizer Co., Boston, Mass.: —
- Swift's Lowell Bone Fertilizer.
- Swift's Lowell Potato Phosphate.
- Swift's Lowell Market Garden.
- Swift's Lowell Tobacco Manure.
- Swift's Lowell Potato Manure.
- Swift's Lowell Animal Brand.
- Swift's Lowell Fruit and Vine.
- Swift's Lowell Dissolved Bone and Potash.
- Swift's Lowell Ground Bone.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash.
- Acid Phosphate.
- Tankage.

Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- The Mapes' Bone Manures.
- The Mapes' Superphosphates.
- The Mapes' Special Crop Manures.
- Tobacco Ash Constituents.
- Tobacco Manure, Wrapper Brand.
- Complete Manure with Ten Per Cent. Potash.
- Economical Potato Manure.
- Fruit and Vine Manure.
- Dissolved Bone-black.
- Nitrate of Soda.
- Sulfate of Potash.

McQuade Bros., West Auburn, Mass.: —
- Ground Bone.

Mitchell Fertilizer Co., Tremley, N. J.: —
- Mitchell's Special Fertilizer.

Geo. L. Monroe, Oswego, N. Y.: —
- Pure Canada Unleached Hard-wood Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Complete Fertilizer.
- Chittenden's Market Garden.
- Chittenden's Potato Phosphate.
- Chittenden's Fish and Potash.
- Chittenden's Ammoniated Bone.
- Chittenden's Universal Phosphate.

New Bedford Product Co., New Bedford, Mass.: —
- Complete Fertilizer.

New England Fertilizer Co., Boston, Mass.: —
- Corn Fertilizer.
- Potato Fertilizer.
- High-grade Truck Fertilizer.

Olds & Whipple, Hartford, Conn.: —
- Complete Tobacco Fertilizer.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Special Potato.
- Star Brand.
- P. & P. Potato.
- A. A. Brand.

Parmenter & Polsey Fertilizer Co. — *Con.*
- Pure Ground Bone.
- Nitrate of Soda.
- Muriate of Potash.

Benjamin Randall, Boston, Mass.: —
- Market Garden.
- Farm and Field.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Pure Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.
- Hubbard's Oats and Top-dressing.
- Hubbard's Soluble Potato Manure.
- Hubbard's Corn and General Crops.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's Grass and Grain Fertilizer.
- Hubbard's All Soils and All Crops Fertilizer.
- Hubbard's Potato Phosphate.
- Hubbard's Corn Phosphate.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Around Fertilizer.
- Complete Potato and Vegetable.
- Complete Corn and Onion.
- Complete Fish and Potash.
- High-grade Grass and Grain.
- High-grade Tobacco and Potato.
- High-grade Oats and Top-dressing.
- High-grade Tobacco.
- Fine-ground Bone.

N. Roy & Son, South Attleborough, Mass.: —
- Animal Fertilizer No 1.
- Animal Fertilizer No. 2.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex Complete Manure for Potatoes, Roots and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Market-garden and Potato Manure.
- Essex A. L. Superphosphate.
- Essex X.X.X. Fish and Potash.
- Essex Odorless Lawn Dressing.
- Essex Special Tobacco Manure.
- Essex Tobacco Starter.
- Essex Corn Fertilizer.

Sanderson Fertilizer and Chemical Co., New Haven, Conn.: —
Sanderson's Old Reliable.
Sanderson's Special Strawberry.
Sanderson's Formula A.
Sanderson's Formula B.

Thomas L. Stetson, Randolph, Mass.: —
Ground Bone.

James P. Trainor, Jamesville, Mass.: —
Ground Bone.

A. L. Warren, Northborough, Mass.: —
Fine-ground Bone.

Darius Whithed, Lowell, Mass.: —
Champion Animal Fertilizer.
Flour of Bone.

E. J. Whitman, Dracut, Mass.: —
Whitman's Potato Fertilizer, "Plowman's."
Whitman's Corn Fertilizer, "Success."
Whitman's Pure Ground Bone.
Whitman's Pure Ground Meat.

Wilcox Fertilizer Works, Mystic, Conn.: —
Potato, Onion and Tobacco Manure.
Complete Bone Superphosphate.
Potato Manure.
Fish and Potash.
Nitrate of Soda.
Muriate of Potash.

Sanford Winter, Brockton, Mass.: —
Pure Fine-ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
Tankage.

Part II. — Report on General Work in the Chemical Laboratory.

CHARLES A. GOESSMANN.

1. Analysis of materials sent on for examination.
2. Notes on wood ashes.

1. Analysis of Materials sent on for Examination.

During the season of 1901, 217 samples of fertilizing materials of various description have been received from farmers within our State. The results of our examination of these substances have been published in three bulletins: No. 74, March; No. 75, July; and No. 77, November, 1901, of the Hatch Experiment Station of the Massachusetts Agricultural College.

Next in importance to the analysis of licensed commercial fertilizers for inspection purposes is the examination of waste and by-products from different manufacturing industries. It has been the aim of the chemical division to encourage the use of different refuse and by-products for manurial purposes wherever the chemical analysis of such material proves them to be of sufficient value to merit their use.

The value of our work in this direction may be seen from year to year by the increased number of all kinds of waste products that are being forwarded to this department for investigation. The increased consumption of this class of materials for manurial purposes cannot but exert an important influence in favor of the agriculturalist on the consumption of commercial fertilizers. The examination of general fertilizing material is carried on free of charge to the farmers in the State, the material being taken up for analysis in the order of arrival of samples at this office.

Following is a list of materials received during the past season, which shows the great variety of substances which are used and valued for manurial purposes, as well as the great variety of work necessarily employed to keep in close touch with the critical examination of this class of materials: —

Wood ashes,	72	Sulfate of ammonia,	1
Complete fertilizers,	27	Acid phosphate,	1
Cotton-seed meal,	17	Tennessee phosphate,	1
Soils,	15	Superphosphate,	1
Muriate of potash,	8	Plain superphosphate,	1
Onions,	8	Marl,	1
Muck,	7	Sewage,	1
Nitrate of soda,	6	Lime-kiln ashes,	1
Tankage,	4	Carbonate of lime,	1
Cotton-hull ashes,	4	Waste from gas house,	1
Ground bone,	3	Pulverized sheep manure,	1
Dissolved bone-black,	3	Hair waste,	1
Blood, bone and meat,	2	Jadoo fibre,	1
Ground fish,	2	Tobacco stems,	1
Concentrated phosphate,	2	Tobacco dust,	1
Mud,	2	Walnut ashes,	1
Hen manure,	2	Pine-wood ashes,	1
Barnyard manure,	2	Ashes from soft coal and saw-dust,	1
Wool waste,	2	Linseed meal,	1
Raw bone meal,	1	Sal-ammoniac,	1
Steamed bone meal,	1	Salt,	1
Condensed bone steam,	1	Asparagus tops,	1
Fresh-cut bone,	1	Milk casein,	1
Burned bone,	1		
Fleshings,	1		

Under the division of general work in the chemical laboratory may also be classed investigations along various lines which are constantly being carried on, such as: a study of the physical and chemical conditions of soil, and their relation to the solubility of different substances applied for fertilizing purposes; investigations of the availability of the different elements of plant food in the soil; new and improved methods for the ash analysis of plants; critical examination of methods of analysis of insecticides and fungicides found in our market; ammonia absorption tests, to determine the most efficient chemical to be used as a fixer

or absorber of ammonia in manure composting; investigation work for the Association of Official Agricultural Chemists, for the establishment of new and improved methods of analyses of agricultural products, etc. The results of the above-stated investigations will be published later, as in the past, whenever the results prove of general interest to the public.

2. Notes on Wood Ashes.

During the season of 1901, 33.1 per cent. of the materials forwarded for analysis consisted of wood ashes, as against 30.8 per cent. the previous year.

The following table shows the general chemical character of wood ashes that have been forwarded for investigation during the season of 1901: —

Analysis of Wood Ashes.

Constituents.	Number of Samples.	
	1900.	1901.
Moisture below 1 per cent.,	1	2
Moisture from 1 to 10 per cent.,	25	28
Moisture from 10 to 20 per cent.,	32	31
Moisture from 20 to 30 per cent.,	13	7
Moisture above 30 per cent.,	1	–
Potassium oxide above 8 per cent.,	1	4
Potassium oxide from 7 to 8 per cent.,	6	5
Potassium oxide from 6 to 7 per cent.,	12	17
Potassium oxide from 5 to 6 per cent.,	25	24
Potassium oxide from 4 to 5 per cent.,	14	10
Potassium oxide from 3 to 4 per cent.,	7	7
Potassium oxide below 3 per cent.,	7	1
Phosphoric acid above 2 per cent.,	6	5
Phosphoric acid from 1 to 2 per cent.,	62	61
Phosphoric acid below 1 per cent.,	4	2
Average per cent. of calcium oxide (lime),	32.51	33.20
Per cent. of mineral matter insoluble in diluted hydrochloric acid: —		
Below 10 per cent.,	15	22
Between 10 and 15 per cent.,	35	24
Between 15 and 20 per cent.,	12	17
Above 20 per cent.,	11	4

From a comparison of the above-stated results of analyses of wood ashes with the results of the previous year, it will be seen that the average standard of composition is somewhat higher than in 1900.

To assist our farmers in selecting the best quality of wood ashes which the market affords, it is imperative that those sending samples for analysis should give us all the general information they possess in regard to the source from which the ashes were obtained, etc. With this idea in view, we caused to be published in our March bulletin, No. 74, a copy of a blank application for free analysis of fertilizing materials, which will hereafter be sent from this office to every applicant for an analysis free of charge. We believe the result of this course will be to impart a more general and intelligent interest in this department of work at the institution, and it will surely make known the names of the licensed as well as the unlicensed dealers in our State. We take this occasion to urge the farmers to patronize the dealers who are on record at our institution, as having complied with our State laws for the regulation of the trade in commercial fertilizers, which includes wood ashes, which are sold in our State for manurial purposes, rather than those who have failed to secure such a license.

In deciding the commercial value of wood ashes, it is well to consider the large quantity of calcium oxide (lime) that is present in a most superior form.

Part III. — Compilation of Analyses of Agricultural Chemicals, Refuse Salts, Ashes, Lime Compounds, Refuse Substances, Guanos, Phosphates and Animal Excrements.

H. D. HASKINS.

1. Chemicals, refuse salts, etc.
2. Ashes, marls, lime compounds, etc.
3. Refuse substances.
4. Guanos, phosphates, etc.
5. Animal excrements, etc.
6. Average per cents. of the different ingredients found in the preceding compilation of analyses, calculated to pounds per ton of 2,000 pounds.

1868 to 1901.

This compilation does not include the analyses made of licensed fertilizers. They are to be found in the reports of the State Inspector of Fertilizers from 1873 to 1895, contained in the reports of the secretary of the Massachusetts State Board of Agriculture for these years, and in the bulletins of the department of chemistry of the Hatch Experiment Station of the Massachusetts Agricultural College since March, 1895.

No valuation is stated in this compilation, as the basis of valuation changes from year to year.

In the following compilation of agricultural chemicals, refuse materials, manurial substances, etc., the signification of the star (*) prefixed to the name of the substance is that the compilation is made up of analyses subsequent to the year 1897. It was believed that a compilation made up of more recent analyses would more nearly represent the present general chemical character of the substances, and would therefore be of more practical value.

It must be understood that the chemical character of many of the refuse substances used for manurial purposes is constantly undergoing changes, due to frequent variations in the parent industry.

As a rule, in all succeeding analyses the essential constituents are determined and stated; blanks do not imply the absence of the non-essentials.

1. *Chemicals, Refuse Salts, etc.*

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
Carbonate of potash,	1	26.88	-	-	-	-	-	-	18.48	-	-	-	-	-	-	-	-	19.52	-	-	-	-	.39
Carnalite,	1	-	-	-	-	-	-	-	13.68	-	-	-	-	-	-	7.66	-	13.19	-	.56	-	41.56	-
* Kainit,	5	1.85	-	-	-	-	13.65	10.90	12.74	-	-	-	-	-	-	18.97	2.37	6.37	-	20.25	-	20.64	2.13
Krugite,	1	4.82	-	-	-	-	-	-	8.42	-	-	-	-	-	-	5.27	12.45	8.79	-	31.94	-	6.63	14.96
* Muriate of potash,	40	1.41	-	-	-	-	54.80	45.40	49.91	-	-	-	-	-	-	6.69	-	.55	-	-	-	48.80	.70
Nitrate of potash,	4	1.30	-	14.58	11.60	12.71	45.62	44.76	45.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Nitrate of soda,	41	1.36	-	16.42	14.14	15.50	-	-	-	-	-	-	-	-	-	35.50	-	-	-	-	-	.50	.50
Nitre salt cake,	2	6.03	-	-	-	2.29	-	-	.87	-	-	-	-	-	-	29.56	-	-	-	47.77	-	-	3.92
Phosphate of potash,	1	3.76	-	-	-	-	-	-	32.55	-	-	37.50	-	37.50	-	-	-	-	-	13.43	-	-	.92
Phosphate of ammonia,	1	6.05	-	-	-	10.37	-	-	-	-	-	43.86	-	-	-	-	-	-	-	12.46	-	-	.82
* Potash refuse from manufacture of cyanide of potash.	1	39.23	-	-	-	.96	-	-	7.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Sulfate of ammonia,	13	1.10	-	21.44	19.44	20.65	-	-	-	-	-	-	-	-	-	-	-	-	-	60.00	-	-	-
* Sulfate of potash,	20	.89	-	-	-	-	53.15	45.70	49.51	-	-	-	-	-	-	4.46	-	1.50	-	45.72	-	-	.75
* Sulfate of potash-magnesia,	13	4.83	-	-	-	-	31.45	19.55	24.91	-	-	-	-	-	-	6.25	2.57	-	-	44.25	-	2.60	1.41
* Silicate of potash,	2	2.07	-	-	-	-	27.62	21.48	24.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Sulfate of magnesia,	10	23.76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.82	17.40	-	36.10	-	-	5.73
* Sulfate of soda,	1	1.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	59.43	-	-	-
Saltpetre waste,	12	2.54	-	3.30	.52	2.22	30.94	1.55	13.66	-	-	-	-	-	-	37.04	.75	.19	-	1.85	-	46.25	-

2. *Ashes, Marls, Lime Compounds, etc.*

Ashes of spent tan bark,	5	4.84	-	-	-	-	2.87	.60	1.81	2.77	.13	1.36	-	-	-	-	31.11	3.39	1.78	-	-	-	25.21
Ashes from cremation of swill,	15	4.86	-	-	-	-	8.83	1.25	3.97	32.36	7.47	14.16	-	-	-	-	33.58	1.87	4.65	-	-	-	21.57
Ashes from blue works,	1	12.14	63.78	-	-	-	-	-	9.02	-	-	-	-	-	-	-	-	-	-	-	-	-	12.30
* Ashes from cremation of garbage,	3	3.01	-	-	-	-	6.01	3.72	5.13	10.21	7.16	8.77	-	-	-	15.65	20.22	1.16	9.22	4.57	10.85	4.75	28.42
* Ashes from hay and straw,	1	.40	-	-	-	-	-	-	1.55	-	-	1.02	-	-	-	-	5.22	-	-	-	-		66.35
* Ashes from jute waste,	1	.19	-	-	-	-	-	-	.51	-	-	.54	-	-	-	3.84	6.04	.39	7.60	-	-	.57	81.02
* Ashes from peach tree trimmings,	1	.54	-	-	-	-	-	-	4.92	-	-	2.44	-	-	-	7.53	18.74	-	10.50	2.20	-	-	13.54
Ammoniated marl,	1	3.31	-	-	-	1.61	-	-	-	-	-	10.39	-	.41	9.98	-	-	-	-	-	-	-	-
* Bleachery refuse,	2	4.19	-	-	-	-	1.24	.35	.79	-	-	-	-	-	-	11.69	35.79	-	-	-	-	-	23.09
Bituminous coal ashes,	2	3.66	-	-	-	-	-	-	.38	-	-	.44	-	-	-	-	1.88	-	-	-	-	-	74.17
* Brick yard ashes,	1	.40	-	-	-	-	-	-	3.59	-	-	1.61	-	-	-	-	23.44	-	-	-	-	-	53.32
* Cotton-seed hull ashes,	21	7.97	-	-	-	-	32.80	15.20	23.93	11.00	6.26	8.70	-	6.88	1.28	-	7.20	12.64	-	-	-	-	18.30
Corn-cob ashes,	1	1.20	-	-	-	-	-	-	7.08	-	-	2.37	-	-	-	-	11.70	-	1.28	-	-	-	52.09
* Carbonate of lime,	1	.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	52.98	-	-	-	-	-	-
Gypse,	1	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50.87	-	-	-	-	-	2.87
* Gas house lime,	3	22.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43.66	8.30	-	20.73	-	-	6.05

2. *Ashes, Marls, Lime Compounds, etc.* — Concluded.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
Green sand marl (Virginia),	1	1.25	-	-	-	-	-	-	1.14	-	-	9.37	-	-	-	-	25.78	-	5.13	-	-	-	41.32
Hard-pine wood ashes,	1	.75	-	-	-	-	-	-	10.16	-	-	2.24	-	-	-	-	24.95	-	-	-	-	-	29.90
* Lime refuse from soda factory,	1	24.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14.86	-	1.36	23.14	-	-	1.63
Lime waste from sugar factory,	1	36.30	-	-	-	-	-	-	.22	-	-	2.25	-	-	-	-	27.51	-	-	-	-	-	.32
Lime,	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93.63	-	-	-	-	-	1.33
* Lime-kiln ashes,	8	10.83	-	-	-	-	4.73	.43	2.09	1.56	.26	.76	-	-	-	-	38.86	1.30	-	-	-	-	5.68
* Leather scrap ashes,	1	.70	-	-	-	-	-	-	3.36	-	-	3.96	-	-	-	-	2.56	-	-	-	-	-	40.00
Logwood ashes,	1	1.50	-	-	-	-	-	-	.08	-	-	2.30	-	-	-	-	3.90	-	-	-	-	-	9.70
Mill ashes,	1	.53	-	-	-	-	-	-	1.60	-	-	.46	-	-	-	-	34.93	1.35	-	-	-	-	36.36
Magnolia ashes (Florida),	1	1.58	-	-	-	-	-	-	2.56	-	-	.45	-	-	-	-	-	-	-	-	-	-	6.12
Massachusetts marls,	7	13.70	-	-	-	-	-	-	.24	2.72	.06	1.05	-	-	-	-	40.50	.64	.69	-	28.57	-	3.44
Marl (North Carolina),	1	.70	-	-	-	-	-	-	.04	-	-	.56	-	-	-	-	21.95	.61	-	-	-	-	50.18
* Nova Scotia plaster (gypsum),	17	6.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33.74	.75	-	44.87	-	-	5.79
Olive earth (Virginia),	1	1.97	-	-	-	-	-	-	.24	-	-	13.73	-	-	-	-	19.16	-	6.00	-	-	-	50.55
Onondaga plaster (New York gypsum),	4	13.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.00	4.66	-	32.50	8.20	-	9.83
* Picker waste ashes,	1	.28	-	-	-	-	-	-	6.56	-	-	1.18	-	-	-	-	-	-	-	-	-	-	63.43

Peat ashes,	1	4.67	-	-	-	-	-	-	.46	-	-	.11	-	-	-	-	2.28	1.63	6.13	-	-	-	45.17
Railroad tie ashes,	1	4.70	-	-	-	-	-	-	.92	-	-	.56	-	-	-	-	2.51	-	-	-	-	-	80.20
Sea-weed ashes,	1	1.47	-	-	-	-	-	-	.92	-	-	.30	-	-	-	8.76	6.06	4.37	-	2.98	-	6.60	63.65
* Wood ashes,	340	11.17	-	-	-	-	8.86	1.12	5.63	2.82	.06	1.32	-	-	-	-	34.54	3.31	7.43	-	-	-	18.28
* Waste lime,	1	.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74.12	-	-	-	-	-	.38
Virginia marls,	2	15.98	-	-	-	-	.61	.37	.49	.09	.08	.09	-	-	-	-	7.25	.21	-	.66	7.25	-	64.23

3. *Refuse Substances.*

Ammoniate,	1	5.88	-	-	-	11.33	-	-	-	-	-	3.43	-	-	-	-	-	-	-	-	-	-	1.38
* Blood and bone,	5	5.97	-	7.19	5.70	6.23	-	-	-	12.86	11.38	12.14	-	4.41	7.73	-	-	-	-	-	-	-	-
Bone soup,	1	82.92	7.07	-	-	1.14	-	-	-	-	-	1.26	-	-	-	-	-	-	-	-	-	-	-
* Bone from fish,	1	8.78	-	-	-	4.82	-	-	-	-	-	23.54	-	8.04	15.50	-	-	-	-	-	-	-	-
* Broom-corn seed,	1	7.40	-	-	-	1.51	-	-	.50	-	-	.57	-	-	-	-	-	-	-	-	-	-	-
* Banana skins,	1	13.99	-	-	-	.24	-	-	5.46	-	-	1.80	-	-	-	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia Majasculas*),	1	16.26	-	-	-	4.25	-	-	.79	-	-	.19	-	-	-	3.53	2.06	1.18	-	-	-	-	5.53
* Concentrated wool washings,	1	41.13	-	-	-	1.09	-	-	10.15	-	-	.10	-	-	-	-	-	-	-	-	-	-	-
* Condensed bone steam,	1	81.75	-	-	-	1.94	-	-	-	-	-	.07	-	-	-	-	-	-	-	-	-	-	-
* Castor-bean pomace,	3	7.87	5.70	5.85	4.98	5.47	3.40	.64	1.20	2.26	1.57	2.12	-	-	-	-	.87	.29	-	-	-	-	1.75
* Cotton-seed meal,	67	6.88	-	7.99	3.24	7.04	1.92	1.41	1.64	3.30	1.71	2.56	-	-	-	-	-	-	-	-	-	-	.28
* Cork dust,	1	.74	-	-	-	.59	-	-	.33	-	-	.10	-	-	-	-	.74	.08	-	-	-	-	.24
* Cotton waste, wet,	3	26.35	-	1.21	.84	1.08	.61	.43	.53	.74	.69	.75	-	-	-	-	2.12	-	-	-	-	-	41.90

3. *Refuse Substances* — Continued.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
* Cotton waste, dry,	7	6.45	-	1.60	.91	1.20	1.40	.88	1.21	.66	.17	.39	-	-	-	-	1.12	-	-	-	-	-	20.78
Cotton dust,	2	32.68	50.93	-	-	.78	-	-	.45	-	-	.32	-	-	-	-	-	-	-	-	-	-	42.22
* Dried blood,	22	9.01	6.37	13.55	8.10	9.84	-	-	-	8.70	1.30	2.07	-	-	-	-	-	-	-	-	-	-	-
Dried soup from meat and bone,	1	14.80	8.40	-	-	9.97	-	-	-	-	-	.53	-	-	-	-	-	-	-	-	-	-	.64
Dried soup from rendering cattle feet,	1	10.80	7.50	-	-	14.47	-	-	-	-	-	.46	-	-	-	-	-	-	-	-	-	-	.26
* Dry ground fish,	21	9.07	-	10.48	7.44	8.56	-	-	-	16.07	5.70	8.98	-	4.21	4.73	-	-	-	-	-	-	-	-
* Damaged grain,	3	42.15	-	1.97	.84	1.44	.43	.16	.28	.83	.35	.55	-	-	-	-	-	-	-	-	-	-	-
* Deposit from Charles River,	1	21.46	-	-	-	.95	-	-	.59	-	-	.74	-	-	-	-	1.81	-	-	-	-	-	44.27
* Dredgings from Cape Cod,	1	18.99	-	-	-	.99	-	-	.13	-	-	.07	-	-	-	-	-	-	2.06	-	-	.54	-
* Deposit from pond,	1	4.01	-	-	-	.41	-	-	.26	-	-	.32	-	-	-	-	.62	-	-	-	-	-	-
Eel grass,	2	35.39	15.60	.96	.70	.83	1.61	.21	.91	.41	.22	.32	-	-	-	1.63	2.13	.11	-	-	-	-	1.06
Felt refuse,	1	29.24	33.53	-	-	5.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Fleshings,	1	6.96	43.14	-	-	7.55	-	-	-	-	-	.31	-	-	-	-	-	-	-	-	-	-	-
* Fresh-cut bone,	1	24.98	-	-	-	3.00	-	-	-	-	-	16.85	-	5.26	11.59	-	-	-	-	-	-	-	-
Fish with 20 to 40 per cent. water,	10	30.19	20.59	7.41	4.22	5.97	-	-	-	8.32	4.68	7.09	.74	2.69	3.64	-	-	-	-	-	-	-	1.68
Fish with more than 40 per cent. water,	10	45.46	15.50	7.60	2.43	4.97	-	-	-	8.56	2.94	5.08	1.17	1.33	2.58	-	-	-	-	-	-	-	1.35

Fresh-water mud,	1	40.37	-	-	-	1.37	-	-	.22	-	-	.26	-	-	-	-	1.27	.29	1.80	-	-	-	18.26
* Ground tobacco stems,	8	8.84	20.20	2.72	.99	2.02	8.18	3.88	6.15	1.15	.32	.62	-	-	-	-	6.75	-	-	-	-	-	1.30
* Ground bones,	135	5.51	66.14	4.99	1.17	3.10	-	-	-	31.42	16.18	24.30	-	7.55	16.73	-	-	-	-	-	-	-	1.08
Glucose refuse,	1	8.10	-	-	-	2.62	-	-	.15	-	-	.29	-	-	-	-	.18	.02	-	-	-	-	.07
Horn shavings,	1	4.83	-	-	-	15.31	-	-	-	-	-	.42	-	-	-	-	-	-	-	-	-	-	-
* Hoof meal,	1	4.10	-	-	-	15.19	-	-	-	-	-	.77	-	-	-	-	-	-	-	-	-	-	-
Horn-and-hoof waste,	3	10.17	7.63	15.49	11.84	13.25	-	-	-	2.30	1.36	1.83	-	-	-	-	-	-	-	-	-	-	.24
* Hair waste,	1	6.52	22.77	-	-	9.22	-	-	.14	-	-	.51	-	-	-	4.10	-	-	-	-	-	-	-
* Hop refuse,	2	84.56	1.71	.69	.49	.59	.06	.05	.05	.11	.10	.10	-	-	-	-	-	-	-	-	-	-	.83
Ivory dust,	1	11.50	52.63	-	-	6.64	-	-	-	-	-	24.56	.97	17.97	5.62	-	-	-	-	-	-	-	-
* Jadoo fibre,	1	11.53	11.60	-	-	.97	-	-	.48	-	-	1.24	-	-	-	-	3.50	-	-	-	-	-	4.05
Jute waste,	1	13.10	-	-	-	1.50	-	-	.08	-	-	.72	-	-	-	-	-	-	-	-	-	-	-
* Kiln dust from brewery,	1	9.72	-	-	-	4.32	-	-	2.16	-	-	.96	-	-	-	-	.78	-	-	-	-	-	7.11
* Linseed meal,	3	8.23	-	6.42	5.26	5.69	1.58	1.46	1.52	1.59	1.36	1.47	-	-	-	-	-	-	-	-	-	-	.58
Lobster shells,	1	7.27	-	-	-	4.50	-	-	-	-	-	3.52	-	-	-	-	22.24	1.30	-	-	-	-	.27
* Meat meal,	1	3.22	8.55	-	-	9.23	-	-	-	-	-	3.08	-	-	-	-	-	-	-	-	-	-	-
Meat mass,	5	12.09	13.60	11.50	9.69	10.44	-	-	-	3.58	.56	2.07	-	-	-	-	-	-	-	-	-	-	.58
Meat scrap,	2	24.79	-	-	-	6.33	-	-	-	-	-	5.79	-	-	-	-	-	-	-	-	-	-	-
Morocco factory waste,	1	22.72	-	-	-	1.16	-	-	.36	-	-	2.56	-	-	-	-	19.60	-	-	1.24	-	-	24.17
* Meat and bone,	6	5.66	-	7.15	4.66	5.30	-	-	-	18.83	14.71	17.15	-	5.61	11.54	-	-	-	-	-	-	-	-
Mill sweepings,	1	9.49	-	-	-	3.76	-	-	.66	-	-	1.18	-	-	-	-	-	-	-	-	-	-	5.01
Madder,	2	11.93	-	-	-	.91	-	-	2.40	-	-	.35	-	-	-	-	3.93	.51	-	-	-	-	4.67

3. *Refuse Substances* — Continued.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
Mussel mud, wet, ...	1	60.01	27.29	–	–	.21	–	–	6.17	–	–	.10	–	–	–	.70	.93	.14	3.48	–	–	–	–
Mussel mud, dry, ...	1	2.24	72.02	–	–	.72	–	–	–	–	–	.35	–	–	–	–	23.39	–	8.26	–	–	–	37.60
* Muck and peat, wet, ...	13	64.49	13.36	1.11	.13	.55	.16	.02	.07	.13	.02	.08	–	–	–	–	.51	–	–	–	–	–	–
* Muck and peat, dry, ...	8	6.67	69.54	2.10	.26	.84	–	–	–	–	–	.31	–	–	–	–	.77	–	–	–	–	–	–
Oleomargarine refuse, ...	1	8.54	14.42	–	–	12.12	–	–	–	–	–	.88	–	–	–	–	–	–	–	–	–	–	.96
* Product from garbage plant, . .	1	4.14	–	–	–	2.56	–	–	.50	–	–	6.92	–	–	–	–	–	–	–	–	–	–	16.48
Pine barren grass, ...	1	8.48	2.40	–	–	.16	–	–	.07	–	–	.18	–	–	–	–	–	–	–	–	–	–	1.67
Pine needles, ...	1	9.48	3.42	–	–	.46	–	–	.03	–	–	.12	–	–	–	–	–	–	–	–	–	–	1.22
Raw wool, ...	1	6.95	7.54	–	–	12.88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.63
Rotten brewers' grain, ...	1	78.77	–	–	–	.72	–	–	.04	–	–	.43	–	–	–	–	.26	.15	–	–	–	–	.59
Refuse from calico works, ...	1	4.07	–	–	–	4.28	–	–	–	–	–	11.95	–	–	–	–	–	–	–	–	–	–	–
* Refuse from glucose factory, . .	1	.13	–	–	–	–	–	–	–	–	–	42.76	–	2.88	39.88	–	38.78	–	2.92	3.00	–	–	–
* Refuse from glass factory, . . .	1	16.48	–	–	–	–	–	–	19.50	–	–	–	–	–	–	6.12	–	–	–	–	–	–	–
Rockweed, green, ...	1	68.50	23.70	–	–	.62	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rockweed, dry, ...	1	10.68	35.75	–	–	1.45	–	–	4.89	–	–	2.75	–	–	–	7.90	7.66	.21	–	–	–	–	10.40
Residue from water filter, . . .	1	94.22	–	–	–	.12	–	–	–	–	–	.05	–	–	–	–	–	–	–	–	–	–	–

Sponge refuse,	1	7.25	-	-	-	2.43	-	-	-	-	-	3.19	-	-	-	-	3.94	1.27	-	-	-	-	39.05
* Sizing paste,	1	61.45	5.58	-	-	1.13	-	-	-	-	-	.02	-	-	-	-	-	-	-	-	-	-	-
* Sizing waste,	1	74.00	-	-	-	.01	-	-	40	-	-	.01	-	-	-	-	-	-	-	-	-	-	1.43
Soap-grease refuse,	2	29.25	51.39	4.20	2.21	3.21	-	-	-	15.37	11.04	13.21	-	-	-	-	-	-	-	-	-	-	1.29
Soup from horse rendering,	1	92.14	-	-	-	1.12	-	-	-	-	-	.14	-	-	-	-	-	-	-	-	-	-	-
* Spent brewers' grain,	1	73.10	-	-	-	1.23	-	-	.07	-	-	.33	-	-	-	-	-	-	-	-	-	-	-
* Spent bone-black,	1	1.16	-	-	-	-	-	-	-	-	-	31.02	-	1.96	29.06	-	-	-	-	-	-	-	-
Sumac waste,	1	63.06	6.80	-	-	1.19	-	-	3.25	-	-	-	-	-	-	-	1.14	3.25	-	-	-	-	2.25
Starch waste from rubber factory,	1	10.01	.23	-	-	.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Sludge from sewage precipitating tanks.	4	37.74	-	1.31	.46	.91	.66	.07	.25	.86	.39	.61	-	-	-	-	3.10	2.19	8.55	.41	4.86	-	28.70
* Sewage,	2	78.07	-	.77	.30	.40	-	-	.27	-	-	.85	-	-	-	-	-	-	-	-	-	.03	20.06
Salt mud,	2	53.37	41.19	.40	.39	.40	.33	.32	.33	-	-	-	-	-	-	.94	.91	.37	4.13	-	-	-	34.88
* Soot,	2	8.60	-	-	-	.77	1.57	.17	.87	.72	.23	.47	-	-	-	-	2.92	1.19	6.38	-	-	-	71.07
* Tankage,	40	7.03	-	9.02	4.11	5.95	-	-	-	21.62	5.65	14.46	-	6.21	8.02	-	-	-	-	-	-	-	-
* Tobacco dust,	4	6.08	-	2.25	1.75	2.06	6.81	2.07	4.33	1.28	.36	.72	-	-	-	-	3.09	-	-	-	-	-	16.59
Tobacco leaves,	1	13.05	21.01	-	-	2.75	-	-	7.24	-	-	.43	-	-	-	-	4.17	2.17	.32	-	-	-	4.17
* Tobacco stalks exposed to the action of weather.	1	7.58	-	-	-	1.18	-	-	.52	-	-	.38	-	-	-	-	-	-	-	-	-	-	1.86
* Teopik fibre,	1	56.54	-	-	-	.53	-	-	1.26	-	-	.55	-	-	-	-	5.15	-	-	-	-	-	.75
Turf,	2	19.29	6.36	1.97	1.91	1.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Undried tankage,	1	29.00	-	-	-	1.06	-	-	-	-	-	3.51	-	2.94	.51	-	-	-	-	-	-	-	-
* Wool waste,	4	6.03	20.10	4.60	.39	2.63	3.74	.29	1.65	1.02	.27	.80	-	-	-	-	2.03	.06	.80	-	-	-	30.69
Wool washings, water,	1	-	-	-	-	-	-	-	3.92	-	-	-	-	-	-	.49	.28	-	-	-	-	-	-

3. *Refuse Substances* — Concluded.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
Wool washings, acid,	1	-	-	-	-	-	-	-	4.20	-	-	-	-	-	-	.40	.61	.20	-	-	-	-	-
Wool washings, alkaline,	1	92.03	3.28	-	-	.09	-	-	1.09	-	-	-	-	-	-	.92	.04	-	-	-	-	-	.22
Whale meat, raw,	1	44.50	1.04	-	-	4.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waste from lactate factory,	1	34.11	-	-	-	.68	-	-	-	-	-	.67	-	-	-	-	22.59	-	-	-	-	-	6.92
* Whalebone scrapings,	1	6.90	-	-	-	13.01	-	-	-	-	-	.26	-	-	-	-	-	-	-	-	-	-	-
* Water abstract of dry forest leaves,	1	99.47	.16	-	-	.004	-	-	.03	-	-	.022	-	-	-	-	.025	-	-	-	-	-	-

4. *Guanos, Phosphates, etc.*

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen, Maximum.	Nitrogen, Minimum.	Nitrogen, Average.	Potash, Maximum.	Potash, Minimum.	Potash, Average.	Total Phosphoric Acid, Maximum.	Total Phosphoric Acid, Minimum.	Total Phosphoric Acid, Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
* Acid phosphate,	18	11.86	-	-	-	-	-	-	-	17.48	11.60	15.52	9.64	3.74	2.13	-	-	-	-	-	-	-	-
* Apatite,	2	.07	-	-	-	-	-	-	-	37.74	32.62	35.18	-	2.09	33.09	-	-	-	-	-	-	-	-
* Bone ash,	1	.34	-	-	-	-	-	-	-	-	-	39.14	-	-	-	-	-	-	-	-	-	-	-
Bone-black,	5	4.60	-	-	-	-	-	-	-	30.54	16.56	28.28	-	-	-	-	-	-	-	-	-	-	3.64
Brockville phosphate,	1	2.50	-	-	-	-	-	-	-	-	-	35.21	-	-	-	-	-	-	-	-	-	-	6.46
Bat guano from Texas,	9	40.09	18.24	10.51	2.58	6.47	-	-	1.31	6.53	1.00	3.76	-	-	-	-	-	-	-	-	-	-	2.00

Bat guano from Florida,	2	15.66	-	-	-	9.74	-	-	1.77	3.44	3.26	3.35	-	-	-	-	-	-	-	-	-	-	19.33
* Bat guano from Havana, Cuba,	1	6.95	-	-	-	6.96	-	-	.53	-	-	5.04	-	-	-	6.17	10.89	-	5.76	-	-	-	.40
Cuban guano,	5	24.27	-	2.74	.63	1.67	-	-	-	16.16	11.54	13.35	-	-	-	-	-	-	-	-	-	-	3.17
Caribbean guano (orchilla),	12	7.31	-	-	-	-	-	-	-	35.43	18.11	26.77	-	-	-	-	39.95	3.29	-	2.68	-	-	1.27
* Dissolved bone-black,	18	11.97	-	-	-	-	-	-	-	20.93	15.60	17.66	14.04	2.94	.76	-	-	-	-	-	-	-	-
* Double superphosphate,	2	6.27	-	-	-	-	-	-	-	50.14	45.42	47.78	18.36	20.97	8.45	-	-	-	-	-	-	-	-
* Dissolved bone meal,	7	5.73	-	4.64	1.66	2.56	-	-	-	22.26	15.04	17.93	3.95	8.72	5.26	-	-	-	-	-	-	-	-
* Damaraland guano,	1	17.70	-	-	-	5.79	-	-	3.53	-	-	14.78	4.90	5.79	4.09	7.03	14.21	2.05	-	5.94	-	5.77	9.26
* Florida rock phosphate,	2	.53	-	-	-	-	-	-	-	40.34	33.10	36.72	-	.10	36.62	-	-	-	-	-	-	-	-
* Florida soft phosphate,	1	4.46	-	-	-	-	-	-	-	-	-	26.48	-	.38	26.10	-	-	-	-	-	-	-	-
* Mona Island guano,	1	13.32	-	-	-	.76	-	-	-	-	-	21.88	-	7.55	14.33	-	37.49	-	-	-	-	-	2.45
* Novassa phosphate,	1	5.77	-	-	-	-	-	-	-	-	-	24.56	-	1.66	22.90	-	-	-	-	-	-	-	-
Odorless phosphate,	6	2.99	-	-	-	-	.52	.04	.38	21.74	18.40	19.54	-	.52	19.82	-	51.42	-	-	-	2.51	-	9.14
* Phosphatic slag,	2	.95	-	-	-	-	-	-	-	19.80	15.70	17.75	-	6.04	13.76	-	39.24	-	-	-	-	-	9.91
Peruvian guano,	26	14.81	37.61	13.50	4.44	7.85	4.08	1.14	2.61	20.60	5.96	15.26	4.57	3.79	6.90	-	-	-	-	-	-	-	6.60
Rat guano from Florida,	1	10.32	-	-	-	3.32	-	-	6.85	-	-	2.30	-	-	-	-	-	-	-	-	-	-	1.15
* South Carolina rock phosphate,	3	.88	-	-	-	-	-	-	-	31.87	25.58	27.98	-	2.63	23.41	-	-	-	-	-	-	-	-
South Carolina floats,	1	.83	-	-	-	-	-	-	-	-	-	23.39	-	2.33	21.06	-	-	-	-	-	-	-	20.16
South American bone ash,	1	7.00	-	-	-	-	-	-	-	-	-	35.89	-	-	-	-	44.89	-	-	-	-	-	4.50
* Tennessee phosphate,	1	.37	-	-	-	-	-	-	.44	-	-	33.00	-	-	-	-	-	-	-	-	-	-	-
Upton phosphate,	1	9.07	-	-	-	-	-	-	-	-	-	40.15	-	37.84	2.31	-	-	-	-	-	-	-	-

5. *Animal Excrement, etc.*

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
* Barnyard manure,	25	71.82	-	.69	.24	.44	.88	.26	.59	.52	.13	.34	-	-	-	-	-	-	-	-	-	-	6.95
* Compost,	1	1.70	-	-	-	.79	-	-	.97	-	-	.56	-	-	-	-	-	-	-	-	-	-	-
Drainage from manure heap,	1	93.20	3.66	-	-	.98	-	-	.88	-	-	.24	-	-	-	-	-	-	-	-	-	-	-
Goose manure,	1	48.92	-	-	-	.21	-	-	.81	-	-	.95	-	-	-	-	-	-	-	-	-	-	-
* Hen manure,	3	34.66	-	1.83	.42	1.18	2.96	.43	1.62	3.93	.63	1.92	-	-	-	-	1.19	.89	-	1.24	-	-	23.50
Hen house refuse,	2	7.37	-	-	-	.71	-	-	1.03	-	-	1.02	-	-	-	-	-	-	-	-	-	-	71.07
Horse manure,	1	11.24	-	-	-	.74	-	-	2.82	-	-	1.46	-	-	-	-	-	-	-	-	-	-	12.60
Poudrette, dry,	1	5.25	35.45	-	-	3.58	-	-	.49	-	-	5.74	-	-	-	-	-	-	-	-	-	-	4.65
* Sheep manure,	4	9.58	17.14	2.97	.85	2.12	3.16	.68	2.03	2.24	.22	1.45	-	-	-	-	-	-	-	-	-	-	33.75

6. Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
1. Chemicals, Refuse Salts, etc.													
Carbonate of potash,	538	-	-	370	-	-	-	390	-	-	-	-	8
Carnalite,	-	-	-	274	-	153	-	264	-	11	-	831	-
* Kainit,	37	-	-	255	-	379	47	127	-	405	-	413	43
Krugite,	96	-	-	168	-	105	249	176	-	639	-	133	299
* Muriate of potash,	28	-	-	998	-	134	-	11	-	-	-	976	14
Nitrate of potash,	26	-	254	905	-	-	-	-	-	-	-	-	-
* Nitrate of soda,	27	-	310	-	-	710	-	-	-	-	-	10	10
Nitre salt cake,	121	-	46	17	-	591	-	-	-	955	-	-	78
Phosphate of potash,	75	-	-	651	750	-	-	-	-	269	-	-	18
Phosphate of ammonia,	121	-	207	-	877	-	-	-	-	249	-	-	16
* Potash refuse from manufacture of cyanide of potash,	785	-	19	147	-	-	-	-	-	-	-	-	-
* Sulfate of ammonia,	22	-	413	-	-	-	-	-	-	1,200	-	-	-
* Sulfate of potash,	18	-	-	990	-	89	-	30	-	914	-	-	15

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
1. Chemicals, Refuse Salts, etc. — Con.													
* Sulfate of potash-magnesium,	97	-	-	498	-	125	51	-	-	885	-	52	28
* Silicate of potash,	41	-	-	491	-	-	-	-	-	-	-	-	-
* Sulfate of magnesia,	475	-	-	-	-	-	56	348	-	722	-	-	115
* Sulfate of soda,	28	-	-	-	-	-	-	-	-	1,189	-	-	-
Saltpetre waste,	51	-	44	273	-	741	15	4	-	37	-	925	-
2. Ashes, Marls, Lime Compounds, etc.													
Ashes of spent tan bark,	97	-	-	36	27	-	622	68	36	-	-	-	504
Ashes from cremation of swill,	97	-	-	79	283	-	672	37	93	-	-	-	431
Ashes from blue works,	243	1,276	-	180	-	-	-	-	-	-	-	-	246
* Ashes from cremation of garbage,	60	-	-	103	175	313	404	23	184	91	217	95	568
* Ashes from hay and straw,	8	-	-	31	20	-	104	-	-	-	-	-	1,327
* Ashes from jute waste,	4	-	-	10	11	77	121	8	152	-	-	11	1,620
* Ashes from peach tree trimmings,	11	-	-	98	49	151	375	-	210	44	-	-	271
Ammoniated marl,	66	-	32	-	208	-	-	-	-	-	-	-	-

* Bleachery refuse,	84	-	-	16	-	234	716	-	-	-	-	-	462
Bituminous coal ashes,	73	-	-	8	9	-	38	-	-	-	-	-	1,483
* Brick yard ashes,	8	-	-	72	32	-	469	-	-	-	-	-	1,066
* Cotton-seed hull ashes,	159	-	-	479	174	-	144	253	-	-	-	-	366
Corn-cob ashes,	24	-	-	142	47	-	234	-	26	-	-	-	1,042
* Carbonate of lime,	9	-	-	-	-	-	1,060	-	-	-	-	-	-
Gypse,	33	-	-	-	-	-	1,017	-	-	-	-	-	57
* Gas house lime,	446	-	-	-	-	-	873	166	-	415	-	-	121
Green sand marl (Virginia),	25	-	-	23	187	-	516	-	103	-	-	-	826
Hard-pine wood ashes,	15	-	-	203	45	-	499	-	-	-	-	-	598
* Lime refuse from soda factory,	481	-	-	-	-	-	297	-	27	463	-	-	33
Lime waste from sugar factory,	726	-	-	4	45	-	550	-	-	-	-	-	6
Lime,	-	-	-	-	-	-	1,873	-	-	-	-	-	27
* Lime-kiln ashes,	217	-	-	42	15	-	777	26	-	-	-	-	114
* Leather scrap ashes,	14	-	-	67	79	-	51	-	-	-	-	-	800
Logwood ashes,	30	-	-	2	46	-	78	-	-	-	-	-	194
Mill ashes,	11	-	-	32	9	-	699	27	-	-	-	-	727
Magnolia ashes (Florida),	32	-	-	51	9	-	-	-	-	-	-	-	122
Massachusetts marls,	274	-	-	5	21	-	810	13	14	-	571	-	69
Marl (North Carolina),	14	-	-	1	11	-	439	12	-	-	-	-	1,004
* Nova Scotia plaster (gypsum),	129	-	-	-	-	-	675	15	-	897	-	-	116
Olive earth (Virginia),	39	-	-	5	275	-	383	-	120	-	-	-	1,011

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
2. Ashes, Marls, Lime Compounds, etc.—Con.													
Onondaga plaster (New York gypsum),	265	-	-	-	-	-	600	93	-	650	164	-	197
* Picker waste ashes,	6	-	-	131	24	-	-	-	-	-	-	-	1,269
Peat ashes,	93	-	-	9	2	-	46	33	123	-	-	-	903
Railroad tie ashes,	94	-	-	18	11	-	50	-	-	-	-	-	1,604
Sea-weed ashes,	29	-	-	18	6	175	121	87	-	60	-	132	1,273
* Wood ashes,	223	-	-	113	26	-	691	66	149	-	-	-	366
* Waste lime,	16	-	-	-	-	-	1,482	-	-	-	-	-	8
Virginia marls,	320	-	-	10	2	-	145	4	-	13	145	-	1,285
3. Refuse Substances.													
Ammoniate,	118	-	227	-	69	-	-	-	-	-	-	-	28
* Blood and bone,	119	-	125	-	243	-	-	-	-	-	-	-	-
Bone soup,	1,658	141	23	-	25	-	-	-	-	-	-	-	-
* Bone from fish,	176	-	96	-	471	-	-	-	-	-	-	-	-
* Broom-corn seed,	148	-	30	10	11	-	-	-	-	-	-	-	-

* Banana skins,	280	-	5	109	36	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia majuscula*),	325	-	85	16	4	71	41	24	-	-	-	-	111
* Concentrated wool washings,	823	-	22	203	2	-	-	-	-	-	-	-	-
* Condensed bone steam,	1,635	-	39	-	1	-	-	-	-	-	-	-	-
* Castor bean pomace,	157	114	109	24	42	-	17	6	-	-	-	-	35
* Cotton-seed meal,	138	-	141	33	51	-	-	-	-	-	-	-	6
* Cork dust,	15	-	12	7	2	-	15	2	-	-	-	-	5
* Cotton waste, wet,	527	-	22	11	15	-	42	-	-	-	-	-	838
* Cotton waste, dry,	129	-	24	24	8	-	22	-	-	-	-	-	416
Cotton dust,	654	1,019	16	9	6	-	-	-	-	-	-	-	844
* Dried blood,	180	127	197	-	41	-	-	-	-	-	-	-	-
Dried soup from meat and bone,	296	168	199	-	11	-	-	-	-	-	-	-	13
Dried soup from rendering cattle feet,	216	150	289	-	9	-	-	-	-	-	-	-	5
* Dry ground fish,	181	-	171	-	180	-	-	-	-	-	-	-	-
* Damaged grain,	843	-	29	6	11	-	-	-	-	-	-	-	-
* Deposit from Charles River,	429	-	19	12	15	-	36	-	-	-	-	-	885
* Dredgings from Cape Cod,	380	-	20	3	1	-	-	-	41	-	-	11	-
* Deposit from pond,	80	-	8	5	6	-	12	-	-	-	-	-	-
Eel grass,	708	312	17	18	6	33	43	2	-	-	-	-	21
Felt refuse,	585	671	105	-	-	-	-	-	-	-	-	-	-
* Fleshings,	139	863	151	-	6	-	-	-	-	-	-	-	-
* Fresh-cut bone,	500	-	60	-	337	-	-	-	-	-	-	-	-

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
3. *Refuse Substances* — Con.													
Fish with 20 to 40 per cent. water,	604	412	119	-	142	-	-	-	-	-	-	-	34
Fish with more than 40 per cent. water,	909	310	99	-	112	-	-	-	-	-	-	-	27
Fresh-water mud,	807	-	27	4	5	-	25	6	36	-	-	-	365
* Ground tobacco stems,	177	404	40	123	12	-	135	-	-	-	-	-	26
* Ground bones,	110	1,323	62	-	486	-	-	-	-	-	-	-	22
Glucose refuse,	162	-	52	3	6	-	4	4	-	-	-	-	1
Horn shavings,	97	-	306	-	8	-	-	-	-	-	-	-	-
* Hoof meal,	82	-	304	-	15	-	-	-	-	-	-	-	-
Horn-and-hoof waste,	203	153	265	-	37	-	-	-	-	-	-	-	5
* Hair waste,	130	455	184	3	10	82	-	-	-	-	-	-	-
* Hop refuse,	1,691	34	12	1	2	-	-	-	-	-	-	-	17
Ivory dust,	230	1,053	133	-	491	-	-	-	-	-	-	-	-
* Jadoo fibre,	231	232	19	10	25	-	70	-	-	-	-	-	81
Jute waste,	262	-	30	2	14	-	-	-	-	-	-	-	-

* Kiln dust from brewery,	194	-	86	43	19	-	16	-	-	-	-	-	142
* Linseed meal,	165	-	114	30	29	-	-	-	-	-	-	-	12
Lobster shells,	145	-	90	-	70	-	445	26	-	-	-	-	5
* Meat meal,	64	171	185	-	62	-	-	-	-	-	-	-	-
Meat mass,	242	272	209	-	41	-	-	-	-	-	-	-	12
Meat scrap,	496	-	127	-	116	-	-	-	-	-	-	-	-
Morocco factory waste,	454	-	23	7	51	-	392	-	-	25	-	-	483
* Meat and bone,	113	-	106	-	343	-	-	-	-	-	-	-	-
Mill sweepings,	190	-	75	13	24	-	-	-	-	-	-	-	100
Madder,	239	-	18	48	7	-	79	10	-	-	-	-	93
Mussel mud, wet,	1,200	546	4	123	2	14	19	3	70	-	-	-	-
Mussel mud, dry,	45	1,440	14	-	7	-	468	-	165	-	-	-	752
* Muck and peat, wet,	1,290	267	11	1	2	-	10	-	-	-	-	-	-
* Muck and peat, dry,	133	1,391	17	-	6	-	15	-	-	-	-	-	-
Oleomargarine refuse,	171	288	242	-	18	-	-	-	-	-	-	-	19
* Product from garbage plant,	83	51	-	10	138	-	-	-	-	-	-	-	330
Pine barren grass,	170	48	3	1	4	-	-	-	-	-	-	-	33
Pine needles,	190	68	9	1	2	-	-	-	-	-	-	-	24
Raw wool,	139	151	258	-	-	-	-	-	-	-	-	-	73
Rotten brewers' grain,	1,575	-	14	1	9	-	5	3	-	-	-	-	12
Refuse from calico works,	81	-	86	-	239	-	-	-	-	-	-	-	-
* Refuse from glucose factory,	3	-	-	-	855	-	776	-	58	60	-	-	-

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

Fertilizer Materials.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
3. *Refuse Substances* — Con.													
* Refuse from glass factory,	330	-	-	390	-	122	-	-	-	-	-	-	-
Rockweed, green,	1,370	474	12	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	214	715	29	98	55	148	153	4	-	-	-	-	208
Residue from water filter,	1,884	-	2	-	1	-	-	-	-	-	-	-	-
Sponge refuse,	145	-	49	-	64	-	79	25	-	-	-	-	781
* Sizing paste,	1,229	112	23	-	.4	-	-	-	-	-	-	-	-
* Sizing waste,	1,480	-	.2	8	.2	-	-	-	-	-	-	-	29
Soap-grease refuse,	585	1,028	22	-	3	-	-	-	-	-	-	-	26
Soup from horse rendering,	1,462	-	25	1	7	-	-	-	-	-	-	-	-
* Spent brewers' grain,	1,462	-	25	1	7	-	-	-	-	-	-	-	-
* Spent bone-black,	23	-	-	-	620	-	-	-	-	-	-	-	-
Sumac waste,	1,261	136	24	65	-	-	23	65	-	-	-	-	45
Starch waste from rubber factory,	200	5	.4	-	-	-	-	-	-	-	-	-	-
* Sludge from sewage precipitating tanks,	755	-	18	5	12	-	62	44	171	8	97	-	574

* Sewage,	1,561	-	8	5	17	-	-	-	-	-	-	1	401
Salt mud,	1,067	824	8	7	-	19	18	7	83	-	-	-	698
* Soot,	172	-	15	17	9	-	58	24	128	-	-	-	1,421
* Tankage,	141	-	119	-	289	-	-	-	-	-	-	-	-
* Tobacco dust,	122	-	41	87	14	-	62	-	-	-	-	-	332
Tobacco leaves,	261	420	55	145	9	-	83	43	6	-	-	-	83
* Tobacco stalks exposed to action of weather,	152	-	24	10	8	-	-	-	-	-	-	-	37
* Teopik fibre,	1,131	-	11	25	11	-	103	-	-	-	-	-	15
Turf,	386	127	39	-	-	-	-	-	-	-	-	-	-
* Undried tankage,	580	-	21	-	70	-	-	-	-	-	-	-	-
* Wool waste,	121	402	53	33	16	-	41	1	16	-	-	-	614
Wool washings, water,	-	-	-	78	-	10	6	-	-	-	-	-	-
Wool washings, acid,	-	-	-	84	-	8	12	4	-	-	-	-	-
Wool washings, alkaline,	1,841	66	2	22	-	18	1	-	-	-	-	-	4
Whale meat, raw,	890	21	97	-	-	-	-	-	-	-	-	-	-
Waste from lactate factory,	692	-	14	-	13	-	452	-	-	-	-	-	138
* Whale bone scrapings,	14	-	260	-	5	-	-	-	-	-	-	-	-
* Water abstract of dry forest leaves,	1,989	3	.08	.6	.44	-	.5	-	-	-	-	-	-
4. Guanos, Phosphates, etc.													
* Acid phosphate,	237	-	-	-	310	-	-	-	-	-	-	-	-
* Apatite,	1	-	-	-	704	-	-	-	-	-	-	-	-
* Bone ash,	7	-	-	-	783	-	-	-	-	-	-	-	-

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Concluded.

Fertilizer Materials.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
4. *Guanos, Phosphates, etc.* — Con.													
Bone-black,	92	-	-	-	566	-	-	-	-	-	-	-	73
Brockville phosphate,	50	-	-	-	704	-	-	-	-	-	-	-	129
Bat guano from Texas,	802	365	129	26	75	-	-	-	-	-	-	-	40
Bat guano from Florida,	313	-	195	35	67	-	-	-	-	-	-	-	387
* Bat guano from Havana, Cuba,	139	-	139	11	101	123	218	-	115	-	-	-	8
Cuban guano,	485	-	33	-	267	-	-	-	-	-	-	-	63
Caribbean guano (orchilla),	146	-	-	-	535	-	799	66	-	54	-	-	25
* Dissolved bone-black,	239	-	-	-	353	-	-	-	-	-	-	-	-
* Double superphosphate,	125	-	-	-	956	-	-	-	-	-	-	-	-
* Dissolved bone meal,	115	-	51	-	359	-	-	-	-	-	-	-	-
* Damaraland guano,	354	-	116	71	296	141	284	41	-	119	-	115	185
* Florida rock phosphate,	11	-	-	-	734	-	-	-	-	-	-	-	-
* Florida soft phosphate,	89	-	-	-	530	-	-	-	-	-	-	-	-
* Mona Island guano,	266	-	15	-	438	-	750	-	-	-	-	-	49

* Novassa phosphate,	115	-	-	-	491	-	-	-	-	-	-	-	-
Odorless phosphate,	60	-	-	8	391	-	1,028	-	-	-	50	-	183
* Phosphatic slag,	19	-	-	-	355	-	785	-	-	-	-	-	198
Peruvian guano,	296	752	157	52	305	-	-	-	-	-	-	-	132
Rat guano from Florida,	206	-	66	137	46	-	-	-	-	-	-	-	23
* South Carolina rock phosphate,	18	-	-	-	560	-	-	-	-	-	-	-	-
South Carolina floats,	17	-	-	-	468	-	-	-	-	-	-	-	403
South American bone ash,	140	-	-	-	718	-	898	-	-	-	-	-	90
* Tennessee phosphate,	7	-	-	9	660	-	-	-	-	-	-	-	-
Upton phosphate,	181	-	-	-	803	-	-	-	-	-	-	-	-
5. Animal Excrement, etc.													
* Barnyard manure,	1,436	-	8.8	11.8	6.8	-	-	-	-	-	-	-	139
* Compost,	34	-	15.8	19.4	11.2	-	-	-	-	-	-	-	-
Drainage from manure heap,	1,864	73	19.6	17.6	4.8	-	-	-	-	-	-	-	-
Goose manure,	978	-	4.2	16.2	19	-	-	-	-	-	-	-	-
* Hen manure,	693	-	23.6	32.4	38.4	-	23.8	17.8	-	24.8	-	-	470
Hen house refuse,	147	-	14.2	20.6	20.4	-	-	-	-	-	-	-	1,421
Horse manure,	225	-	14.8	56.4	29.2	-	-	-	-	-	-	-	252
Poudrette, dry,	105	709	71.6	9.8	115	-	-	-	-	-	-	-	93
* Sheep manure,	192	343	42.4	40.6	29	-	-	-	-	-	-	-	675

Part IV. — Compilation of Analyses of Fruits, Garden Crops and Insecticides.

H. D. HASKINS.

1. Analyses of fruits.
2. Analyses of garden crops.
3. Relative proportions of phosphoric acid, potassium oxide and nitrogen in fruits and garden crops.
4. Analyses of insecticides.

A computation of the results of a chemical analysis of twenty prominent garden crops shows the following average relative proportion of the three essential ingredients of plant food: —

	Parts.
Nitrogen,	2.2
Potassium oxide,	2.0
Phosphoric acid,	1.0

One thousand pounds of green garden vegetables contain, on the above stated basis of relative proportion of essential constituents of plant food: —

	Pounds.
Nitrogen,	4.1
Potassium oxide,	3.9
Phosphoric acid,	1.9

The weight and particular stage of growth of the vegetables when harvested control, under otherwise corresponding conditions, the actual consumption of each of these articles of plant food. Our information regarding these points is still too fragmentary to enable a more detailed statement here beyond relative proportions. It must suffice for the present to call attention to the fact that a liberal manuring within reasonable limit pays, as a rule, better than a scanty one. (C. A. Goessmann.)

1. Analyses of Fruits.

Fertilizing Constituents of Fruits (Parts per Thousand).

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Ericaceæ: —										
* Cranberries,	996	–	1.8	.9	.1	.3	.1	.3	–	–
* Cranberries,	894	.8	–	1.0	–	.2	.1	.3	–	–
Rosaceæ: —										
Apples,	831	.6	2.2	.8	.6	.1	.2	.3	.1	–
* Apples,	799	1.3	4.1	1.9	.3	.3	.3	.1	–	–
* Peaches,	884	–	3.4	2.5	–	.1	.2	.5	–	–
Pears,	831	.6	3.3	1.8	.3	.3	.2	.5	.2	–
Strawberries,	902	–	3.3	.7	.9	.5	–	.5	.1	.1
* Strawberries,	–	–	5.2	2.6	.2	.7	.4	1.0	–	–

Fertilizing Constituents of Fruits — Concluded.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Rosaceæ — *Con.*										
* Strawberry vines,	–	–	33.4	3.5	4.5	12.2	1.3	4.8	–	–
Cherries,	825	–	3.9	2.0	.1	.3	.2	.6	.2	.1
Plums,	838	–	2.9	1.7	–	.3	.2	.4	.1	–
Saxifragaceæ: —										
* Currants, white,	–	–	5.9	3.1	.2	1.0	.3	1.1	–	–
* Currants, red,	871	–	4.1	1.9	.2	.8	.3	.9	–	–
Gooseberries,	903	–	3.3	1.3	.3	.4	.2	.7	–	–
Viticeæ: —										
Grapes,	830	1.7	8.8	5.0	.1	1.0	.4	1.4	.5	.1
Grape seed,	110	19.0	22.7	6.9	.5	5.6	1.4	7.0	.8	.1

2. Analyses of Garden Crops.

Fertilizing Constituents of Garden Crops (Parts per Thousand).

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ: —										
Mangolds,	880	1.8	9.1	4.8	1.5	.3	.4	.8	.3	.9
* Mangolds,	873	1.9	12.2	3.8	1.3	.6	.4	.9	–	–
Mangold leaves,	905	3.0	14.6	4.5	2.8	1.6	1.4	1.0	.8	2.3
Sugar beets,	805	1.6	7.1	3.8	.6	.4	.6	.9	.3	.3
* Sugar beets,	869	2.2	10.4	4.8	.8	.6	.4	1.0	.1	–
Sugar beet tops,	840	2.0	9.6	2.8	2.3	.9	1.1	1.2	.2	.3
Sugar beet leaves,	897	3.0	15.3	4.0	2.0	3.1	1.7	.7	.8	1.3
Sugar beet seed,	146	–	45.3	11.1	4.2	10.2	7.3	7.5	2.0	1.9

Fertilizing Constituents of Garden Crops — Continued.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ — *Con.*										
* Red beets, ...	877	2.4	11.3	4.4	.9	.5	.3	.9	–	–
Spinach, ...	903	2.4	16.0	2.7	5.7	1.9	1.0	1.6	1.1	1.0
* Spinach, ...	922	3.4	9.6	9.6	2.1	.6	.5	.5	–	–
Compositæ: —										
Lettuce, common, ...	940	–	8.1	3.7	.8	.5	.2	.7	.3	.4
Head lettuce, ...	943	2.2	10.3	3.9	.8	1.5	.6	1.0	.4	.8
* Head lettuce, ...	970	1.2	–	2.3	.2	.3	.1	.3	–	–
Roman lettuce, ...	925	2.0	9.8	2.5	3.5	1.2	.4	1.1	.4	.4
Artichoke, ...	811	–	10.1	2.4	.7	1.0	.4	3.9	.5	.2
* Artichoke, Jerusalem, ...	775	4.6	–	4.8	–	–	–	1.7	–	–

Convolvulaceæ : —										
Sweet potato,	758	2.4	7.4	3.7	.5	.7	.3	.8	.4	.9
Cruciferæ : —										
White turnips,	920	1.8	6.4	2.9	.6	.7	.2	.8	.7	.3
* White turnips,	895	1.8	10.1	3.9	.8	.9	.3	1.0	1.0	–
White turnip leaves,	898	3.0	11.9	2.8	1.1	3.9	.5	.9	1.1	1.2
* Ruta-bagas,	891	1.9	10.6	4.9	.7	.9	.3	1.2	–	–
Savoy cabbage,	871	5.3	14.0	3.9	1.4	3.0	.5	2.1	1.2	1.1
White cabbage,	900	3.0	9.6	4.3	.8	1.2	.4	1.1	1.3	.5
* White cabbage,	984	2.3	–	3.4	.3	.2	.1	.2	–	–
Cabbage leaves,	890	2.4	15.6	5.8	1.5	2.8	.6	1.4	2.4	1.3
Cauliflower,	904	4.0	8.0	3.6	.5	.5	.3	1.6	1.0	.3
Horse-radish,	767	4.3	19.7	7.7	.4	2.0	.4	2.0	4.9	.3
Radishes,	933	1.9	4.9	1.6	1.0	.7	.2	4.5	.3	.5
Kohlrabi,	850	4.8	12.3	4.3	.8	.4	.8	2.7	1.1	.6

Fertilizing Constituents of Garden Crops — Continued.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Cucurbitaceæ: —										
Cucumbers,	956	1.6	5.8	2.4	.6	.4	.2	1.2	.4	.4
Pumpkins,	900	1.1	4.4	.9	.9	.3	.2	.7	.3	.4
Gramineæ: —										
Corn, whole plant, green,	829	1.9	10.4	3.7	.5	1.4	1.1	1.0	.3	.5
* Corn, whole plant, green,	786	4.1	–	3.8	.5	1.5	.9	1.5	–	–
Corn, kernels,	144	16.0	12.4	3.7	.1	.3	1.9	5.7	.1	.2
* Corn, kernels,	100	18.2	–	4.0	.3	.3	2.1	7.0	–	–
* Corn, whole ears,	90	14.1	–	4.7	.6	.2	1.8	5.7	–	–
* Corn stover,	282	11.2	37.4	13.2	7.9	5.2	2.6	3.0	–	–

Leguminosæ: —										
Hay of peas, cut green,	167	22.9	62.4	23.2	2.3	15.6	6.3	6.8	5.1	2.0
* Cow-pea (*Dolichos*), green,	788	2.9	–	3.1	.6	3.0	1.0	1.0	–	–
* Small pea (*Lathyrus Sylvestris*), dry,	90	38.5	–	25.7	4.7	17.9	5.0	9.0	–	–
Peas, seed,	143	35.8	23.4	10.1	.2	1.1	1.9	8.4	.8	.4
Pea straw,	160	10.4	43.1	9.9	1.8	15.9	3.5	3.5	2.7	2.3
Garden beans, seed,	150	39.0	27.4	12.1	.4	1.5	2.1	9.7	1.1	.3
Bean straw,	166	–	40.2	12.8	3.2	11.1	2.5	3.9	1.7	3.1
* Velvet beans, kernel,	111.6	31.1	–	13.2	–	–	–	7.7	–	–
* Velvet beans, with pod,	115.2	19.6	–	13.1	–	–	–	8.4	–	–
* Leaves and stems of velvet beans,	58.8	28.6	–	–	–	–	–	–	–	–
Liliaceæ: —										
* Asparagus,	942	3.3	–	3.29	–	–	–	1.08	–	–
Asparagus,	933	3.2	5.0	1.2	.9	.6	.2	.9	.3	.3
Onions,	860	2.7	7.4	2.5	.2	1.6	.3	1.3	.4	.2
* Onions,	892	–	4.9	1.8	.1	.4	.2	.7	–	–

Fertilizing Constituents of Garden Crops — Concluded.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Solanaceæ: —										
Potatoes,	750	3.4	9.5	5.8	.3	.3	.5	1.6	.6	.3
* Potatoes,	798	2.1	9.9	2.9	.1	.1	.2	.7	–	–
Potato tops, nearly ripe,	770	4.9	19.7	4.3	.4	6.4	3.3	1.6	1.3	1.1
Potato tops, unripe,	825	6.3	16.5	4.4	.3	5.1	2.4	1.2	.8	.9
* Tomatoes,	940	1.7	–	3.6	–	.3	.2	.4	–	–
Tobacco leaves,	180	34.8	140.7	40.7	4.5	50.7	10.4	6.6	8.5	9.4
* Tobacco, whole leaf,	103.1	24.3	–	57.9	24.7	45.8	13.8	4.3	16.3	1.59
Tobacco stalks,	180	24.6	64.7	28.2	6.6	12.4	.5	9.2	2.2	2.4
* Tobacco stems,	106	22.9	140.7	64.6	3.4	38.9	12.3	6.0	–	–

Umbelliferæ : —										
Carrots,	850	2.2	8.2	3.0	1.7	.9	.4	1.1	.5	.4
* Carrots,	898	1.5	9.2	5.1	.6	.7	.2	.9	–	–
Carrot tops,	822	5.1	23.9	2.9	4.7	7.9	.8	1.0	1.8	2.4
Carrot tops, dry,	98	31.3	125.2	48.8	40.3	20.9	6.7	6.1	–	–
Parsnips,	793	5.4	10.0	.4	.2	1.1	.6	1.9	.5	.4
* Parsnips,	803	2.2	–	6.2	.1	.9	.5	1.9	–	–
Celery,	841	2.4	17.6	7.6	–	2.3	1.0	2.2	1.0	2.8

Many of the foregoing analyses were compiled from the tables of E. Wolff. Those marked with a star (*) are from analyses made at the Massachusetts State Agricultural Experiment Station, Amherst, Mass., and since 1895, at the chemical division of the Hatch Experiment Station of the Massachusetts Agricultural College.

3. Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Fruits and Garden Crops.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Fruits.			
Ericaceæ: —			
* Cranberries, ...	1	3.0	–
* Cranberries, ...	1	3.33	2.66
Rosaceæ: —			
Apples, ...	1	2.7	2.0
* Apples, ...	1	1.9	1.3
* Peaches, ...	1	1.3	–
Pears, ...	1	3.6	1.2
Strawberries, ...	1	1.4	–
* Strawberries, ...	1	2.6	–
* Strawberry vines, . . .	1	.7	–
Cherries, ...	1	3.3	–
Plums, ...	1	4.3	–
Saxifragaceæ: —			
* Currants, white, ...	1	2.8	–
* Currants, red, ...	1	2.1	–
Gooseberries, ...	1	1.9	–

3. *Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops* — Continued.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Fruits — Con.			
Viticeæ: —			
Grapes,	1	3.6	1.2
Grape seed,	1	1.0	2.7
Garden Crops.			
Chenopodiaceæ: —			
Mangolds,	1	6.0	2.3
* Mangolds,	1	4.2	2.1
Mangold leaves,	1	4.5	3.0
Sugar beets,	1	4.2	1.8
* Sugar beets,	1	4.8	2.2
Sugar beet tops,	1	2.3	1.7
Sugar beet leaves,	1	5.7	4.3
Sugar beet seed,	1	1.5	–
* Red beets,	1	4.1	3.3
Spinach,	1	1.7	3.1
* Spinach,	1	19.2	6.8
Compositæ: —			
Lettuce, common,	1	5.3	–
Head lettuce,	1	3.9	2.2
* Head lettuce,	1	7.7	4.0
Roman lettuce,	1	2.3	1.8
Artichoke,	1	.63	–
* Artichoke, Jerusalem,	1	2.8	2.7

3. *Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops* — Continued.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Garden Crops — Con.			
Convolvulaceæ: —			
Sweet potato,	1	4.6	3.0
Cruciferæ: —			
White turnips,	1	3.6	2.3
* White turnips,	1	3.9	1.8
White turnip leaves,	1	3.1	3.3
* Ruta-bagas,	1	4.1	1.6
Savoy cabbage,	1	1.9	2.5
White cabbage,	1	4.1	1.7
* White cabbage,	1	11.0	7.6
Cabbage leaves,	1	4.1	1.7
Cauliflower,	1	2.3	2.5
Horse-radish,	1	3.9	2.2
Radishes,	1	3.2	3.8
Kohlrabi,	1	1.6	1.8
Cucurbitaceæ: —			
Cucumbers,	1	2.0	1.3
Pumpkins,	1	.6	.7
Gramineæ: —			
Corn, whole plant, green,	1	3.7	1.9
* Corn, whole plant, green,	1	2.2	2.8
Corn kernels,	1	.6	2.8
* Corn kernels,	1	.6	2.6

3. Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops — Continued.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Garden Crops — Con.			
Gramineæ — *Con.*			
* Corn, whole ears, ...	1	.8	2.5
* Corn stover, ...	1	4.4	3.7
Leguminosæ : —			
Hay of peas, cut green, . .	1	3.4	3.4
* Cow-pea (*Dolichos*), green, .	1	3.1	2.9
* Small pea (*Lathyrus Sylvestris*), dry.	1	3.4	4.2
Peas, seed, ...	1	1.2	4.3
Pea straw, ...	1	2.8	4.0
Garden beans, seed, . . .	1	1.2	4.0
Bean straw, ...	1	3.3	–
* Velvet beans, kernel, . . .	1	1.7	4.0
* Velvet beans, with pod, . .	1	1.56	2.3
* Leaves and stems of velvet beans,	–	–	–
Liliaceæ : —			
* Asparagus, ...	1	3.05	3.06
Asparagus, ...	1	1.3	3.6
Onions, ...	1	1.9	2.1
* Onions, ...	1	2.6	–
Solanaceæ : —			
Potatoes, ...	1	3.6	2.1
* Potatoes, ...	1	4.1	3.0
Potato tops, nearly ripe, . .	1	2.7	3.1

3. *Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops* — Concluded.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Garden Crops — Con.			
Solanaceæ — *Con.*			
Potato tops, unripe,	1	3.7	5.3
* Tomatoes,	1	8.7	4.5
Tobacco leaves,	1	6.2	5.3
* Tobacco, whole leaf,	1	13.46	5.65
Tobacco stalks,	1	3.1	2.7
* Tobacco stems,	1	10.7	3.8
Umbelliferæ : —			
Carrots,	1	2.7	2.0
* Carrots,	1	5.7	1.7
Carrot tops,	1	2.9	5.1
Carrot tops, dry,	1	8.0	5.1
Parsnips,	1	3.8	2.8
* Parsnips,	1	3.3	1.2
Celery,	1	3.5	1.1

4. Analyses of Insecticides.

	Moisture.	Arsenious Oxide.	Copper Oxide.	Lead Oxide.	Zinc Oxide.	Barium Oxide.	Acetic Acid.	Nicotine.	Mercury.	Sulphur.	Sulphuric Acid.	Chlorine.	Calcium Oxide.	Potassium Oxide.	Ferric and Aluminic Oxides.	Insoluble Matter in Hydrochloric Acid.
Average of twelve analyses, Paris green,	1.22	57.91	32.08	-	-	-	4.74	-	-	-	-	-	-	-	-	.20
Average of four analyses, "Lion brand new-process Paris green."	4.64	54.91	7.93	-	-	-	-	-	-	-	6.65	-	15.76	.35	-	1.00
Average of fourteen analyses of Paris green collected in the general markets in 1900-1901.	.81	57.73	29.45	-	-	-	-	-	-	-	-	-	-	-	-	-
Pink arsenoid (lead arsenite),	.35	40.16	-	53.83	-	-	-	-	-	-	-	-	-	-	-	-
Green arsenoid (copper arsenite),	1.44	50.77	31.90	-	-	-	-	-	-	-	-	-	-	-	-	-
White arsenoid (barium arsenite),	2.35	31.90	-	.96	-	48.31	-	-	-	-	-	3.19	-	-	-	-
Laurel green,	7.64	7.34	13.50	-	-	-	-	-	-	-	-	-	26.31	-	-	-
Bug death,	.03	-	-	1.58	78.86	-	-	-	-	-	-	-	-	-	3.80	-
Sulphatine,	1.40	-	2.61	-	-	-	-	-	-	48.28	4.73	-	18.60	-	-	1.63
Death to rose bugs,	2.95	-	1.05	-	-	-	-	-	-	34.53	4.35	-	17.76	-	-	.49
Professor De Graff's carpet bug destroyer,	95.81	-	-	-	-	-	-	-	.78	-	.48	.27	-	.26	.90	-
Oriental fertilizer and bug destroyer,	87.14	2.38	-	-	-	-	-	-	-	-	.64	3.00	-	3.50	-	-
Non-poisonous potato bug destroyer,	-	-	-	-	-	-	-	-	-	-	-	-	68.20	-	1.38	1.50
Tobacco liquor,	37.71	-	-	-	-	-	-	2.12	-	-	-	-	3.07	6.55	.23	-
Tobacco liquor,	40.89	-	-	-	-	-	-	.53	-	-	-	-	1.47	16.34	.01	-
Tobacco liquor,	-	-	-	-	-	-	-	4.68	-	-	-	-	-	-	-	-
Nicotina,	10.00	-	-	-	-	-	-	-	-	-	-	-	4.45	9.15	-	2.12
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.34
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.12
Peroxide of silicate,	1.65	.57	.33	-	-	-	-	-	-	-	49.66	-	41.18	-	-	2.31

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Assistants: E. B. HOLLAND, P. H. SMITH, JR., J. W. KELLOGG.

PART I. — OUTLINE OF YEAR'S WORK.

- A. Correspondence.
- B. Extent of chemical work.
- C. Character of chemical work.
  - (*a*) Water.
  - (*b*) Dairy products and feed stuffs.
  - (*c*) Chemical investigation.
- D. Cattle feed inspection.
- E. Dairy legislation.
- F. Miscellaneous.

PART II. — DAIRY AND FEEDING EXPERIMENTS.

- A. Effect of feed on the composition of milk, butter fat, and on the consistency or body of butter.
- B. Notes on summer forage crops.

PART III. — COMPILATIONS.

- A. Composition and digestibility of fodder articles.
- B. Fertilizer ingredients of fodder articles.
- C. Analyses of dairy products.
- D. Coefficients of digestibility of American feed stuffs.

Part I. — Outline of Year's Work.

J. B. LINDSEY.

A. Correspondence.

The general correspondence of this division has increased considerably during the last five years, due especially to the establishment of the feed control, and to the work in connection with the dairy law. More than the usual number of inquiries have been received relative to milk, cream, water, feed stuffs and methods of feeding. Some letters can be answered very quickly, while others require time and study. The total number of letters written during the year ending December 15 has been 2,186.

B. Extent of Chemical Work.

In the last report attention was called to the fact that the ever-increasing demand on the chemists' time for work of a routine character — the analyses of water, milk, cream and feed stuffs — very seriously interfered with the extent of experimental work. This has been particularly the case the past year, due largely to the amount of time required in connection with the dairy law. In fact, the work of investigation has been seriously curtailed, which is much to be regretted.

There have been sent in for examination 242 samples of water, 164 of milk, 1,557 of cream, 15 of pure and process butter, 48 of oleomargarine, 106 of feed stuffs and 5 of miscellaneous substances. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 148 samples of milk and cream, 80 of butter fat and 563 of fodders and feed stuffs.

There have also been collected, under the provision of the feed law, and tested, either individually or in composite, 694 samples of concentrated feed stuffs. This makes a total of 3,622 substances analyzed during the year, as against 3,036 last year and 2,045 in the previous year. Work on the pentosans and galactan, not included in the above, has been done for the Association of Official Agricultural Chemists. In addition, forty-five candidates have been examined and given certificates to operate Babcock machines in creameries and milk depots, and 5,041 pieces of glassware have been tested for accuracy.

C. Character of Chemical Work.

(*a*) *Water.* — It has been the custom, ever since the establishment of the Massachusetts State Experiment Station, in 1882, to make sanitary analyses of drinking waters free of cost to all citizens of Massachusetts. Work of this character has increased until it has become quite burdensome. Acting with the approval of the Experiment Station committee, the following rules were adopted, and went into effect July 1: —

1. Hereafter, all parties wishing to secure a sanitary analysis of water at the Hatch Experiment Station must make known their desire by postal or letter, whereupon a glass bottle, securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express to the applicant.
2. According to a recent official ruling, no party shall be allowed to have more than *two* samples of water tested at this station free of cost in a single month. Additional analyses may be obtained within this time at a cost of two dollars each, providing the resources of the station permit.

Heretofore, parties have been allowed to send in any number of samples, at any time, in any kind of vessel. One result of this custom was, that the station often received more samples than could be properly handled, and other work was crowded to one side. Now it is possible to regulate the number of samples by the time at our disposal. Because of the large amount of work on hand, it has become

necessary to refuse water samples during the months of November and December of the present year. Again, many persons had only an imperfect understanding of the method of taking and shipping a sample; consequently, the water was often received in improper condition, rendering the results of very questionable value. At present, a clean, glass-stoppered bottle is shipped the applicant, together with full instructions. The chemist, therefore, feels reasonably sure that the sample under examination is a fair one, and the results obtained are of a more positive character.

Samples are received not only from farmers, but from persons following various trades and professions. They are practically all from wells, springs and ponds in towns and villages not having a public water supply. Many are of fair quality, others quite suspicious, while some are entirely unfit for use. Some samples have been found to contain lead, due to the use of lead pipe. Drinking water thus polluted results in serious cases of lead poisoning, as many persons have found, to their sorrow. All parties are *cautioned never to use lead pipe to conduct water intended for drinking or cooking purposes.* It is not considered necessary to publish the results of the various analyses made, as they convey no particular information that could be of general interest.

(*b*) *Dairy Products and Feed Stuffs.* — More than the usual number of samples of milk and cream have been received during the past year. They were sent largely for the purpose of determining the amount of butter fat they contained. Some farmers are desirous of knowing the quality of milk produced by their animals, while others, who sell cream to the different creameries, wish to ascertain how closely the station tests agree with those made by the local creamery. Quite frequently samples of milk are received from milkmen whose product has been found to be below the standard by the inspector or milk contractor. In such cases the determination of both total solids and fat is made. The results of all analyses are returned within a few days, together with as full information as possible.

Printed circulars are also sent, containing information concerning the quality of the milk produced by different breeds of animals, and the necessary instruction relative to the best methods to be used in estimating the butter producing capacity of dairy herds.

In addition to the above, this division examines milk, cream and butter collected in western Massachusetts by the agent of the Dairy Bureau. The work is confined largely to the detection of oleomargarine, and is paid for by the Bureau, at a definite price for each determination.

The number of feed stuffs sent for examination was a trifle less than usual, due to the fact that quite thorough information of this character is now furnished in the feed bulletins issued from time to time by this division. During the winter and early spring a considerable number of samples of cotton-seed meal were received, tested, and the results returned without delay.

(*c*) *Chemical Investigation.* — So far as possible, it is the intention of this division to continue its investigation of some of the various dairy and feeding problems demanding solution. At present the time is devoted to the examination of butter fat, the manufacture of butter, and the digestibility of concentrated feed stuffs and summer forage crops. Work of this character is to be found in connection with Part II. of this report.

D. Cattle Feed Inspection.

The inspection of cattle feeds has been carried on in much the same manner as in previous years. Bulletin No. 71, comprising forty pages, was issued early in the year. This contains analyses of 653 cattle feeds, 33 poultry feeds, 46 so-called condimental foods for horses, cattle and poultry, together with full discussion of the results obtained. The interested reader is referred to it. When warranted, additional information is issued as press bulletins and sent to about one hundred newspapers in the State. Should any material be found seriously adulterated, a special circular is sent at once to the grain dealers in every town. Two complete inspections have been made during the present year, resulting in the collection of 698 samples. They are now

under examination, and the results thus far obtained allow the following deductions: —

(*a*) The larger part of the *cotton-seed meal* is now guaranteed, and is of excellent quality. A few unguaranteed meals were found mixed with more or less hulls. *Farmers are strongly urged to buy only guaranteed meals.*

(*b*) *Gluten meal* and *feed* are nearly always accompanied with a guaranty, and are free from any foreign admixtures.

(*c*) *Wheat bran* and *middlings* are seldom adulterated. Purchasers are recommended, however, to give preference to those articles branded with the name of reputable manufacturers, or to examine the article closely before buying, in order to note its quality.

(*d*) *Mixed feed*, so called, consists of the entire wheat offal or mixtures of bran, coarse and flour middlings. The larger the proportion of flour middlings, the more valuable the feed. Different brands show noticeable variations in the proportions of the several ingredients. Farmers can obtain a very *desirable* mixed feed by mixing equal parts by weight of bran and flour middlings or red dog flour. Such a feed will be decidedly preferable to many of the brands now on the market, and the cost will not be increased. Most mixed feeds are entirely free from adulteration. A few samples were found containing a considerable quantity of ground corn cobs. Some were marked Kentucky Milling Company, others Kentucky, and a few were without brand. Several samples contained a noticeable amount of wheat screenings. Mixed feed containing cobs can generally be recognized by the hard, woody nature of the material when chewed. A close inspection of the feed will reveal the presence of screenings. Consumers are *especially cautioned* against such feeds.

(*e*) Oat offal, the refuse from the oat meal mills, contains large quantities of oat hulls. Two brands, namely, "X" and "Boston," were practically all hulls. The price of the offal varied from $16 to $27 a ton. It is relatively a *very expensive feed.*

(*f*) Dried brewers' grains and malt sprouts offer cheap sources of protein, provided they can be obtained.

In general, it can be said that the number of brands is

increasing each year, practically all of which are the by-products from different manufacturing industries. The better class of feed stuffs, as put out by firms of established reputation, are not adulterated ; irresponsible firms, however, are making systematic attempts to put out inferior goods. This is noticed especially in the persistent attempt to sell cotton-seed meal mixed with fine-ground hulls for genuine meal ; in the substitution of fine-ground corn cobs for middlings in mixed feeds ; in the offering of fine-ground rice hulls to dealers for the purpose of adulterating standard grains ; and in the use of oat offal rather than ground oats in the mixing of the so-called provender (cracked corn and ground oats).

The following is the text of the present feed stuff law : —

[Chapter 117, Acts and Resolves of 1897.]

Section 1. The director of the Hatch Experiment Station of the Massachusetts Agricultural College is hereby authorized and directed, in person or by deputy, to take samples not exceeding two pounds in weight from any lot or package of concentrated commercial feed stuff, used for feeding any kind of farm live stock, which may be in the possession of any manufacturer, importer, agent or dealer, cause the same to be analyzed for the amount of crude protein and crude fat contained therein, as well as for other ingredients if thought advisable, and cause the results of the analyses to be published from time to time in especially prepared bulletins, with such additional information as circumstances advise : *provided, however*, that in publishing the results of the analyses, the name of the jobbers or local dealers selling the said feed stuffs shall not be used, but the commodity analyzed shall be identified and described by the name of the manufacturer, or the commercial name or designation by which it is known in the trade.

Section 2. Whenever requested, said samples shall be taken in the presence of the party or parties in interest or their representative, and shall in all cases be taken from a parcel or number of packages which shall not be less than five per cent. of the whole lot inspected, shall be thoroughly mixed and then divided into two equal samples and put in glass vessels and carefully sealed, and a label placed on each vessel stating the name or brand of the feed stuff or material sampled, the name of the manufacturer when possible, the name of the party from whose

stock the sample was taken, and the time and place of taking; said label shall be signed by the director, or his deputy, and by the party or parties in interest or their representative if present at the taking and sealing of the samples. One of said duplicate samples shall be retained by the director and the other by the party whose stock was sampled.

SECTION 3. To defray the expenses of collecting and analyzing the samples and of publishing the results, the sum of twelve hundred dollars shall be allowed and paid annually in semi-annual payments from the treasury of the Commonwealth into the treasury of the Massachusetts Agricultural College.

SECTION 4. This act shall take effect on the first day of July in the year eighteen hundred and ninety-seven.

The above law simply provides for collecting and analyzing the samples and for the publication of the results. It prevents the publication of the names of the jobbers or local dealers selling the feed stuffs. It was the best that could be procured at the time. In the light of our experience, it is believed that this law should be changed and a more comprehensive one made, with the following points emphasized: —

1. An explicit statement of those feed stuffs included and those not included within the law.

2. The tagging of each package with the brand, name and place of business of the manufacturer or sponsor, net weight, and a guaranty of protein, fat and fibre.

3. The prohibiting of adulteration of any grain or recognized by-product with any foreign material whatsoever, unless the name and quantity of said material is clearly specified on the package.

4. The filing upon request by each manufacturer of a certified sample of each distinct brand of feed stuff offered for sale.

5. Instructions concerning the collection and analyzing of the feed stuffs and the publication of the results.

6. A penalty for obstructing an agent in the collecting of samples, and for selling articles which are not as represented.

7. The appropriation from the State treasury of at least double the sum now appropriated for the purpose of carrying out the provisions of the new law.

Laws similar to the one outlined are now in operation in Maine, New Hampshire, Vermont, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Maryland and Wisconsin. It is believed that the enactment of a law including the points outlined above would be for the true interest of producers and consumers alike.

E. Dairy Legislation.

The Massachusetts Legislature during the session of 1901–1902 passed the following law: —

[Chapter 202.]

An Act to provide for the protection of dairymen.

Be it enacted, etc., as follows:

Section 1. All bottles, pipettes or other measuring glasses used by any person, firm or corporation, or by any employee or agent thereof, at any creamery, cheese factory, condensed milk factory, milk depot, or other place, in this state, in determining by the Babcock test, or by any other test, the value of milk or cream received from different persons or associations at such creameries, factories or milk depots as a basis of payment for such milk or cream, shall before use be tested for accuracy. Such bottles, pipettes or measuring glasses shall bear in ineffaceable marks or characters the evidence that such test has been made by the authority named in section two of this act. No inaccurate bottles, pipettes or glasses shall bear such marks or characters, but when found inaccurate shall be marked "Bad."

Section 2. It is hereby made the duty of the director of the Hatch Experiment Station of the Massachusetts Agricultural College, or of some competent person designated by him, to test all bottles, pipettes or other measuring glasses, as required by section one of this act. The director of the experiment station shall receive for such service the amount of the actual cost incurred, and no more, the same to be paid by the persons or corporations for whom it is rendered.

Section 3. Within six months after this act takes effect, and once each year thereafter, the director of the Hatch Experiment Station, or his authorized agent, shall inspect at the expense of the owners all centrifugal or other machines used by any person, firm or corporation, or by any agent or employee thereof, for the testing of milk or cream in fixing the value thereof; and the director of the experiment station or his authorized agent shall cause all

such machines to be put into condition to obtain accurate results with the Babcock test or other tests, at the expense of the owners thereof. Such machines may be replaced by new ones at the option of the persons to whom they belong.

SECTION 4. No person shall, either by himself or in the employ of any other person, firm or corporation, manipulate the Babcock test, or any other test, whether mechanical or chemical, for the purpose of measuring the butter fat contained in milk or cream as a basis for determining the value of such milk or cream, or of butter or cheese made from the same, without first obtaining a certificate from the director of the Hatch Experiment Station that he or she is competent to perform such work. Rules governing applications for such certificates and the granting of the same shall be established by the said director. The fee for issuing such a certificate shall in no case exceed two dollars, the same to be paid by the applicant to the said director, to be used in meeting the expenses incurred under this act.

SECTION 5. It shall be the duty of the director of the Hatch Experiment Station to test farmers' samples of milk or cream by the Babcock method, and report the results of each test, the cost of such test to be paid by the farmer. The director shall also test by the Babcock method, samples of milk or cream sent from any creamery, factory or milk depot in the state by its proper representative, the actual cost of such tests to be borne by the sender. The experiment station shall publish and distribute such information concerning the Babcock test, and the taking and forwarding of samples, as it deems necessary under this section.

SECTION 6. Any person violating any provision of this act shall be fined not more than twenty-five dollars for the first offence and not more than fifty dollars for each subsequent offence.

SECTION 7. This act shall take effect on the first day of July in the year nineteen hundred and one. [*Approved March 26, 1901.*

The execution of the above law having been referred to this division, a circular was prepared, giving the text of the law, together with such rules and regulations as it seemed wise to make for the carrying out of its several provisions. There seeming to be doubt in some instances as to whom the law applied, the following interpretation was made, which is believed to be correct and in accordance with the spirit of the law: —

1. All parties employing the Babcock or similar test

simply as a protection against adulteration, the results of which in no way affect the price of milk or cream to either the producer or consumer, shall be considered exempt from the law.

2. All parties employing the Babcock or similar test (as described in section 4) for the purpose of measuring the butter fat contained in the milk or cream, as a basis for determining or fixing the value of such milk or cream (to either producer or purchaser), shall be considered subject to the requirements of the law.

The law practically resolves itself into three sections: (1) the testing of glassware for accuracy of graduation; (2) the examination of candidates for proficiency in operating the test; (3) the inspection of Babcock machines.

Inspection of Glassware. — The scale on the neck of the cream, whole and skim milk bottles is tested for accuracy of graduation by the mercury method, as described by Farrington & Woll in their work entitled "Testing milk and its products." Pipettes and acid measures are tested for accuracy by carefully measuring the amount of water they deliver. The following limits of error were adopted: —

	Capacity.	Single Graduation.	Limit of Error.
	Per Cent.	Per Cent.	Per Cent.
Cream bottles, Connecticut,	30-35-40	.50	.50
Cream bottles, Connecticut,	50	1.00	.50
Cream bottles, Bartlett,	25	.20	.20
Milk bottles, common,	10	.20	.20
Milk bottles, Ohlsson,	5	.10	.10
Milk bottles, Wagner,	8	.10	.10
Skim milk bottles, double quantity,	2.00	.10	.10
Skim milk bottles, Ohlsson,	.50	.05	.02
Skim milk bottles, improved Ohlsson,	.25	.01	.01
Skim milk bottles, Wagner,	.50	.05	.02
Skim milk bottles, improved Wagner,	.25	.01	.10
	Cubic Centimetre.	Cubic Centimetre.	Cubic Centimetre.
Pipettes, cream,	18.00	-	.10
Pipettes, milk,	17.60	-	.10
Acid measures,	17.50	-	.20

All glassware found to be correct is marked "Mass. Ex. St.," by means of a sand blast, working under twenty-five pound pressure. The necessary air pressure for the blast is obtained by a double-acting power air pump,* with a thirty-gallon reservoir.

It became necessary at first to test the ware in use by all creameries and milk depots. Now, practically none is received from these sources, but rather from the large supply houses, who furnish tested ware whenever requested. There has been examined to date 5,041 pieces, of which 291 pieces, or 5.77 per cent., have been found to be incorrect. One order from a large supply house, numbering 441 pieces, contained 149 pieces, or 33.8 per cent., incorrectly graduated. The wisdom, therefore, of this section of the law is apparent without further argument.

Manufacturers are now inclined to be more careful concerning the quality and accuracy of glassware supplied, for the reason that a large part is examined by the several experiment stations before coming into the hands of the users.

Examination of Candidates.† — It seemed wise to require candidates to present themselves at the station laboratory for examination. In all, 45 candidates have been examined to date. Scarcely any were found to be free from faults, but the larger number appeared to understand the general principles of manipulation. A few were noticeably careless, and had but an imperfect understanding of the process. As much instruction as possible was given in the time at our disposal, an especial effort being made to correct the serious faults. In furtherance of this idea, the following circular concerning the points especially to be observed in making the test was printed, and a copy given to each party examined: —

1. Milk or cream should be carefully and thoroughly mixed, — *never* by shaking the sample, but by gently rotating it and by pouring from one vessel to another. All cream adhering to the

* No. 3, A. Babcock & Bishop Company, New York.

† The inspection of the glassware and the examination of candidates were largely in charge of Mr. E. B. Holland, who gave these matters very careful attention.

sides and stopper of the retaining vessel must be incorporated, and the resulting mixture should show no solid particles of fat. A small fine wire sieve is of great value in detecting the imperfect (lumpy) condition of a sample and in preparing the same for pipetting.

2. Pipette immediately after preparing the sample, filling the pipette *slowly*, and taking care to avoid air bubbles. Hold the pipette in a *vertical* position when lowering the liquid to the mark, and always read with the entire meniscus above the line. In transferring milk or cream to the test bottles, avoid, so far as possible, the smearing of the entire neck with the liquids.

3. Cream testing above 25 per cent. of fat should always be weighed, as accurate results cannot be secured with the pipette.

4. In adding the acid, turn the bottle so as to wash down all milk or cream adhering to the sides of the neck, and mix at once. Rotate the bottle until all the lumps of casein are thoroughly dissolved, and the resulting mixture is *black* in color. Never slight the mixing, and avoid throwing the fat up into the neck.

5. Whirl at least five, two, and two minutes. In filling with hot water, allow the water to run down the sides of the neck, and thus avoid stirring up the contents of the bottle.

6. In reading the column of fat, it is safer to use a pair of dividers than to trust to the unaided eye; read the *centre* of the fat column from the *lowest* to the *highest* limit.

Inspection of Machines. — The inspection of Babcock machines, in accordance with section 3 of the law, is now in progress. Mr. Nathan J. Hunting, a graduate of the college in the class of 1901, is charged with the execution of this work. It is not possible at present to make any definite report, other than to state that a number of machines have thus far been condemned and others have been ordered repaired.

F. Miscellaneous.

Under this heading it is desired to call attention to the compilation of analyses of cattle feeds and dairy products prepared by Messrs. Holland and Smith, and published as Part III. Tables of a similar character were printed in the ninth report of this station. The present compilation — representing the analysis of different substances made since the establishment of the Massachusetts State Experiment

Station — has been thoroughly revised, and some feeds that are no longer on the market or were of only temporary interest have been omitted. This is especially true of a number of concentrated by-products, where the process of manufacture has been noticeably changed and improved.

Tables showing the coefficients of digestibility of all American feed stuffs, similar to those published in the ninth report, are also presented. Work of this nature requires a great amount of time, and severely taxes the resources of the station staff.

PART II. — DAIRY AND FEEDING EXPERIMENTS.

J. B. LINDSEY.*

A. EFFECT OF FEED ON THE COMPOSITION OF MILK AND ON THE CONSISTENCY OR BODY OF BUTTER.

Experiments of this character have been in progress since 1898. A general outline of those previously completed will be found in the preceding (thirteenth) report of this station (pages 14–33).

During the autumn and winter of 1900–1901 another series was conducted, for the purpose of noting particularly the effect of cotton-seed meal with a minimum amount of oil, and likewise with the addition of cotton-seed oil, on the relative proportions of the several ingredients in milk and butter fat and on the body of the butter. It is intended at present only to briefly outline the character of the experiment, and to call attention to a few of the more important facts; the full data will be published later.

Plan of Experiment. — Ten cows were divided into two herds of five each. During the first period both herds received the same or so-called standard ration. During the three subsequent periods Herd I. continued to receive the standard ration as in the first period, and in case of Herd II. a portion of the standard ration was replaced by cotton-seed meal, cotton-seed oil and Cleveland flax meal.

TABLE I. — *Duration of Experiment.*

PERIODS.	Dates of Experiment.	Length in Weeks.
First period, both herds standard ration, . .	Nov. 17 through Dec. 7,	3
Second period, Herd II., cotton-seed ration, .	Jan. 5 through Feb. 8,	5
Third period, Herd II., cotton-seed oil ration, .	Feb. 23 through April 6,	6
Fourth period, Herd II., Cleveland flax meal ration.	April 20 through May 16,	4

* Together with E. B. Holland, P. H. Smith, Jr., and J. W. Kellogg.

TABLE II. — *Approximate Daily Rations (Pounds).*

First period: both herds, standard ration.

HERDS.	Standard Ration.	Cotton-seed Meal.	Cotton-seed Oil.	Cleveland Flax Meal.	First Cut Hay.	Rowen.
Herd I.,	9	–	–	–	8–12	10
Herd II.,	9	–	–	–	8–12	10
Second period: Herd I., standard ration; Herd II., cotton-seed ration.						
Herd I.,	9	–	–	–	8–12	10
Herd II.,	5	3	–	–	8–12	10
Third period: Herd I., standard ration; Herd II., cotton-seed oil ration.						
Herd I.,	9	–	–	–	8–12	10
Herd II.,	5	3	.5	–	8–12	10
Fourth period: Herd I., standard ration; Herd II., Cleveland flax meal ration.						
Herd I.,	9	–	–	–	8–12	10
Herd II.,	4	–	–	3	8–12	10

The standard ration consisted of 3 pounds of wheat bran, 5 pounds of ground oats and ½ pound each of cotton-seed and gluten meal. It is not to be inferred that this so-called standard ration is superior to all other rations, but simply that it was thought to be a safe and desirable ration, and likely to produce normal milk and butter. It was intended to secure cotton-seed meal with a minimum percentage of oil, but, in spite of all efforts, the lowest obtainable contained 8 per cent. The extra cotton-seed oil fed in the third period was mixed with the grain ration.

Table III. — *Average Composition of Milk.*

First period: both herds standard ration.

Herds.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Ash.
Herd I., ...	14.15	5.00	9.15	.538	.73
Herd II., ...	14.27	4.93	9.34	.546	.72

Second period: Herd I., standard ration; Herd II., cotton-seed ration.

Herd I., ...	14.16	5.06	9.10	.550	.73
Herd II., ...	14.30	4.98	9.32	.562	.71

Third period: Herd I., standard ration; Herd II., cotton-seed oil ration.

Herd I., ...	14.22	5.05	9.17	.557	.73
Herd II., ...	14.75	5.40	9.35	.565	.72

Fourth period: Herd I., standard ration; Herd II., Cleveland flax meal ration.

Herd I., ...	14.32	5.12	9.21	.565	.74
Herd II., ...	14.81	5.06	9.75	.616	.74

Composite samples of milk were taken from each herd for five days in each week, and tested for total solids, fat, nitrogen and ash. The milk from each herd showed no noticeable variations in composition during the first two periods. In the third, or cotton-seed oil period, the milk of Herd I. remained as in the preceding periods, while the total solids and fat of Herd II. showed an increase of about .40 per cent. at the beginning of the period, and this increase maintained itself until the close of the period. The solids not fat, nitrogen and ash remained unchanged. In the fourth, or Cleveland flax meal period, the milk from Herd I. remained practically unchanged, increasing a trifle in all ingredients, due to advanced lactation. In case of the milk from Herd II. the fat decreased to the percentage produced in the second period (before the cotton-seed oil was fed),

while the total solids remained as high as in the cotton-seed oil period. The solids not fat and the nitrogen showed a noticeable increase. The increase of the nitrogen percentage apparently explains why the total solids did not show the same relative decrease as did the total fat. The ash remained unaffected.

TABLE IV. — *Average Analysis of Butter Fat.*

Number Samples, Each Herd.	Saponification Equivalent.		Insoluble Acids.		Reichert Meissl Number.		Melting Point (Degrees C.).		Iodine Number.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
First period: both herds standard ration.										
6 samples, .	229.3	231.8	88.95	88.72	29.02	30.54	33.44	32.46	28.28	29.29
Second period: Herd I., standard ration; Herd II., cotton-seed meal ration.										
10 samples, .	228.7	230.3	88.03	87.81	29.08	30.32	33.75	34.10	27.98	29.58
Third period: Herd I., standard ration; Herd II., cotton-seed oil ration.										
12 samples, .	233.3	225.3	88.19	88.57	28.97	28.82	34.04	36.46	27.35	33.78
Fourth period: Herd I., standard ration; Herd II., Cleveland flax meal ration.										
8 samples, .	228.9	228.4	–	–	28.08	26.81	34.04	33.42	29.21	29.87

It will be seen that, excepting for minor variations, the butter fat produced by Herd I. remained unchanged throughout the several periods. In the cotton-seed meal period the fat produced by Herd II. increased a little in its melting point, but otherwise no particular change is noted. In the cotton-seed oil period the fat in case of Herd II. showed a decrease in its Reichert Meissl number and a noticeable increase in the melting point and iodine number, as compared with previous periods. In the Cleveland flax meal period the butter fat produced by Herd II. became similar in composition to that produced by Herd I., excepting the Reichert

Meissl number, which somewhat decreased. This decrease in volatile acids was also noticed in a previous experiment, when linseed meal was fed with apparently unsatisfactory results, so far as the quality of the butter was concerned.

Two lots of butter were made weekly, the same conditions prevailing in case of each herd. These butters were scored by W. A. Gude of New York and O. Douglass of Boston : —

TABLE V. — *Average Butter Scores.*

First period : both herds standard ration.

SCORERS.	FLAVOR.		BODY.		COLOR.		SALT.		STYLE.		TOTAL.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Gude, .	36.5	38.0	24.8	24.6	15.0	15.0	10	10	5	5	91.3	92.6
Douglass, .	-	-	-	-	-	-	-	-	-	-	93.6	93.7
Second period : Herd I., standard ration ; Herd II., cotton-seed meal ration.												
Gude, .	36.8	37.3	24.5	24.8	14.9	14.8	10	10	5	5	91.2	91.9
Douglass, .	-	-	-	-	-	-	-	-	-	-	93.8	94.1
Third period : Herd I., standard ration ; Herd II., cotton-seed oil ration.												
Gude, .	36.9	37.0	24.1	24.6	14.9	15.0	10	10	5	5	90.9	91.6
Douglass, .	-	-	-	-	-	-	-	-	-	-	92.7	93.1
Fourth period : Herd I., standard ration ; Herd II., Cleveland flax meal ration.												
Gude, .	36.0	35.0	25.0	24.7	15.0	15.0	10	10	5	5	91.0	89.7
Douglass, .	-	-	-	-	-	-	-	-	-	-	91.6	90.1
Standard Score.												
Gude, .	45.0	45.0	25.0	25.0	15.0	15.0	10	10	5	5	100.0	100.0
Douglass, .	50.0	50.0	20.0	20.0	15.0	15.0	10	10	5	5	100.0	100.0

So far as the judgment of practical scorers is concerned, little difference was noted in the flavor and body of the butter made from the different rations. The butter made

from the cotton-seed meal and from the cotton-seed oil rations appears to have been a trifle more satisfactory, on the whole, than that made from the standard ration, and that made from the Cleveland flax meal ration a trifle less so. Judging from the remarks of Mr. Gude, the tendency of the standard ration and the cotton-seed meal ration was to produce a hard, crumbly butter, which the cotton-seed oil counteracted, causing it to become softer and more yielding in its nature.

The observation of the writer was that the butter produced by the cotton-seed meal ration was a little softer than that produced by the standard ration.

The butter produced by the cotton-seed oil ration was noticeably softer and more yielding than that produced by the standard ration. The difference was not sufficient to render the former butter objectionable, from a commercial stand-point. At a temperature of 80° F. the standard ration butter stood up well and could be handled, although somewhat soft; while the cotton-seed oil butter was handled with difficulty, appearing to have lost its consistency or body.

The butter produced by the flax meal ration was not noticeably different from that produced by the standard ration butter. Most of the cows during this period were in advanced stage of lactation, so that the results obtained are not particularly satisfactory.

TABLE VI. — *Average Degrees of Penetration* (*Millimeters*).

First Period.		Second Period.		Third Period.		Fourth Period.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
4.7	4.6	4.5	4.4	4.4	5.0	5.2	5.4

By degrees of penetration is meant the number of millimeters a small glass plunger loaded with mercury will penetrate into butter when dropped from a definite height. No differences were noted excepting in the third period, when the plunger penetrated deeper into the butter produced by the cotton-seed oil, showing its more yielding character.

Results. — The following are the most important results :—

1. Cotton-seed meal with a minimum percentage of oil did not alter the percentage composition of the milk.

2. The addition of one-half to three-fourths of a pound of cotton-seed oil to the cotton-seed meal appeared to increase the fat percentage in the milk about four-tenths of one per cent. (5 to 5.4), and this increase was maintained during the six weeks of the feeding period.

3. The substitution of Cleveland flax meal for the cotton-seed meal and oil resulted in a decrease of the fat in the milk to about the percentage found in the first period, while the nitrogen percentage was increased. This change in composition was probably due to the removal of the cotton-seed oil from the ration, and not to the influence of the flax meal.

4. Cotton-seed meal with minimum oil caused no marked variation in the chemical composition of the butter fat.

5. The addition of cotton-seed oil to the cotton-seed meal ration produced a noticeable increase in the melting point and iodine number of butter fat.

6. Cotton-seed meal with a minimum oil produced a firm butter.

7. The addition of cotton-seed oil, while it increased the melting point of the butter fat, produced a softer, more yielding butter than that produced by either the cotton-seed meal or the standard ration.

8. An excess of cotton-seed oil in the ration is likely to affect the health of the animal.

B. Notes on Summer Forage Crops.

J. B. LINDSEY.

This division has carried on experiments with green crops for a number of years, in order to ascertain those best suited to local conditions for summer forage. The results of these observations were published in Bulletin No. 72, issued in the spring of 1901. Observations with a number of crops have been continued the past season.

Wheat and Winter Vetch. — This is one of the earliest spring forage crops. It has been grown at this station for two consecutive years, with very satisfactory results. A full description of the crop and method of cultivation is found in the above bulletin. About one-third of an acre was seeded the first of the present September, and has made an excellent growth and promises well for the coming season. The experience obtained with this mixture leads to the conclusion that it is decidedly preferable to winter rye for early forage, although not ready to cut until a week later. The vetch thus far has proved perfectly able to withstand the winter. The digestibility of this mixture, both green and in the form of hay, has been made, but the results are not yet available for publication.

Corn and Cow Peas. — It has been the intention, so far as practicable, to grow mixtures of legumes and non-legumes, in order to increase the amount of protein in the several forage crops. For a number of years corn and medium green soy beans have been grown together quite successfully. The past season Longfellow corn and black cow-peas were sown together in rows three and one-half feet apart, with an Eclipse corn planter, at the rate of ten quarts of corn and seven quarts of peas to the acre. The soil was rather of a

light loam, and somewhat sensitive to drought. The rainfall proved sufficient, and the yield was heavy, being at the rate of twenty-three tons to the acre. The peas spread out, nearly covering the space between the rows, twining themselves at the same time about the stalks of corn. The crop was harvested with some difficulty, because of its tangled condition, but proved quite satisfactory for green fodder. This mixture, as well as that of corn and soy beans, will be grown again the coming season. It is believed that such fodder combination will enable the farmer to get along with less purchased grain.

Barnyard Millet. — Several plots of this fodder were grown and fed the past season. The results fully confirm the opinion concerning this crop expressed in last year's report. Its chief value is unquestionably for green forage. The first crop, sown about the middle of May, can be cut as early as July 15 to 20, and if successive seedings are made, green forage may be had until into September. Cutting should begin just before the heads appear, and the crop is at its best for eight to ten days thereafter. After it is headed it becomes tough, and animals refuse quite a portion of it. In order, therefore, to secure green fodder from such a source for a considerable period, it is necessary that small pieces of ground be seeded every ten days. This millet succeeds best upon warm, rather heavy, moist, fertile soils. Such conditions favor the production of sixteen to twenty tons to the acre, and even larger yields have been reported. Upon light soils the writer prefers corn, or corn and beans, for a soiling crop, after August 15. The millet when in blossom is probably as nutritious as corn fodder at the same stage of growth. Corn fodder, however, can be grown until more or less eared, and still be readily eaten, and in this condition the corn will naturally have a superior feeding value.

Barnyard millet is unsuited for hay, and is only to be preferred to corn for silage when for any reason it is not possible to secure a crop of corn.

PART III. — COMPILATION OF ANALYSES OF FODDER ARTICLES AND DAIRY PRODUCTS, MADE AT AMHERST, MASS., 1868–1901.

Prepared by E. B. HOLLAND and P. H. SMITH, JR.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES.
- I. — Green fodders.
  - (*a*) Meadow grasses and millets.
  - (*b*) Cereals.
  - (*c*) Legumes.
  - (*d*) Mixed and miscellaneous.
- II. — Silage.
- III. — Hay and dry, coarse fodders.
  - (*a*) Meadow grasses and millets.
  - (*b*) Cereals.
  - (*c*) Legumes.
  - (*d*) Straw.
  - (*e*) Mixed and miscellaneous.
- IV. — Vegetables, fruits, etc.
- V. — Concentrated feeds.
  - (*a*) Protein.
  - (*b*) Starchy.
  - (*c*) Poultry.

B. FERTILIZER INGREDIENTS OF FODDER ARTICLES. (For classification, see A and C.)

C. ANALYSES OF DAIRY PRODUCTS.

A. Composition and Digestibility of Fodder Articles.

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or air-dry substance.						Water-free substance.				Fresh or air-dry substance.				Water-free substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I.—Green Fodders.																			
(a) *Meadow Grasses and Millets.*																			
Johnson grass (*Andropogon halepensis*),	1	75*	1.4	1.2	8.9	13.2	0.3	4.6	35.7	53.0	1.2	-	-	-	-	-	-	-	-
Orchard grass,	7	70	2.1	2.9	10.4	13.7	0.9	9.7	34.8	45.6	3.0	-	-	-	-	-	-	-	-
Tall oat grass,	4	70	1.6	2.3	10.8	14.7	0.6	7.5	36.0	49.0	2.2	-	-	-	-	-	-	-	-
Japanese millet (variety uncertain),	3	80	1.1	1.2	7.1	10.2	0.4	6.0	35.4	50.9	2.1	-	-	-	-	-	-	-	-
Pearl millet (*Pennisetum spicatum*),	1	75	1.7	1.8	8.6	12.6	0.3	7.2	34.4	50.5	1.0	-	-	-	-	-	-	-	-
Fox-tail millets:																			
Common millet (*Chætochloa italica*),	16	75	1.2	1.9	8.1	13.2	0.6	7.4	32.4	52.7	2.5	1.2	5.8	9.0	0.4	4.7	23.0	35.8	1.7†
Canary bird seed millet (*Chætochloa italica*).	1	80	1.6	1.0	7.1	10.0	0.3	5.0	35.5	50.0	1.5	-	-	-	-	-	-	-	-
Early harvest millet (*Chætochloa italica*),	1	80	1.4	1.1	7.4	9.7	0.4	5.5	37.0	48.5	2.0	-	-	-	-	-	-	-	-
Golden millet (*Chætochloa italica*),	1	75	1.5	1.0	8.7	13.4	0.4	4.0	34.8	53.4	1.6	-	-	-	-	-	-	-	-
Hungarian grass (*Chætochloa italica*),	3	75	1.8	2.4	7.2	13.1	0.5	9.8	28.6	52.3	2.0	1.5	5.1	8.9	0.3	6.3	20.3	35.6	1.3
Japanese millet (*Chætochloa italica*),	12	80	1.2	1.7	6.2	10.5	0.4	8.2	31.2	52.5	2.0	1.0	4.1	7.1	0.3	5.0	20.6	35.7	1.3‡
Barnyard millet (*Panicum crus-galli*),	7	80	1.7	1.9	6.5	9.5	0.4	9.5	32.5	47.6	1.9	1.2	4.3	6.5	0.3	5.8	21.5	32.4	1.2

Broom-corn millets.	Millet (*Panicum miliaceum*),	1	80	1.1	1.1	5.3	11.7	0.8	5.8	26.5	58.4	3.8	-	-	-	-	-	-	-	-
	Broom-corn millet (*Panicum miliaceum*),	1	80	1.2	1.3	6.4	10.7	0.4	6.5	32.0	53.5	2.0	-	-	-	-	-	-	-	-
	Japanese broom-corn millet (*Panicum miliaceum*).	2	80	1.2	0.9	6.2	11.4	0.3	4.5	31.0	57.0	1.5	-	-	-	-	-	-	-	-
	Hog millet (*Panicum miliaceum*),	1	80	1.4	1.5	6.5	10.2	0.4	7.5	32.5	51.0	2.0	-	-	-	-	-	-	-	-
	(*b*) *Cereal Fodders.*																			
	Barley,	1	75	2.1	3.2	9.4	9.6	0.7	12.9	37.6	38.1	2.8	2.3	5.7	6.8	0.4	9.3	22 9	27.1	1.7
	Barley in milk,	1	75	1.2	2.6	7.3	13.2	0.7	10.4	29.0	52.8	2.8	1.9	4.5	9.4	0.4	7.5	17.7	37.5	1.7§
	Corn fodder,	39	80	0.9	1.6	4.5	12.6	0.4	8.0	22.5	63.0	2.0	1.0	2.7	9.3	0.3	4.8	13.5	46.6	1.5
	Sweet corn stover,	2	80	1.2	1.4	4.9	12.0	0.5	7.1	24.4	60.0	2.4	-	-	-	-	-	-	-	-
	Oats (stage uncertain),	6	75	2.0	3.5	7.5	11.2	0.8	13.8	30.0	45.0	3.1	2.5	4.0	7.1	0.6	9.9	15.9	28.4	2.1
	Oats in bloom,	1	75	1.7	1.6	9.0	12.0	0.7	6.5	36.0	48.1	2.8	-	-	-	-	-	-	-	-
	Oats in milk,	1	75	1.5	2.7	8.6	11.5	0.7	10.9	34.4	45.9	2.7	-	-	-	-	-	-	-	-
	Oats, ripe,	1	70	1.9	1.8	10.9	14.6	0.8	6.1	36.4	48.7	2.6	-	-	-	-	-	-	-	-
	Rye,	2	75	1.4	1.9	8.0	13.2	0.5	7.5	31.8	52.9	2.1	1.4	4.6	8.8	0.3	5.4	18.1	35.4	1.3‖
	Winter rye in bloom,	1	75	1.6	2.7	8.3	11.8	0.6	10.7	33.0	47.3	2.6	-	-	-	-	-	-	-	-
	(*c*) *Legumes.*																			
	Alfalfa (*Medicago sativa*),	6	75	2.0	3.4	7.7	11.4	0.5	13.6	30.7	45.8	1.9	-	-	-	-	-	-	-	-
	Horse bean (*Faba vulgaris*),	1	85	0.9	2.5	4.3	6.9	0.4	16.7	28.6	46.0	2.7	-	-	-	-	-	-	-	-
	Soy bean (*Glycine hispida*),	14	75	2.6	4.4	6.8	10.1	1.1	17.5	27.1	40.4	4.6	3.3	3.2	7.4	0.6	13.1	12.7	29.5	2.5¶
	Soy bean (early white),	4	75	3.2	4.2	5.6	11.3	0.7	16.7	22.3	45.3	2.7	3.2	2.6	8.3	0.4	12.5	10.5	33.1	1.5

* Water in green fodders varies with stage of growth and rainfall.

† Same coefficients used as for Hungarian grass.

‡ Same coefficients used as for barnyard millet.

§ Same coefficients used as for barley.

‖ Average coefficients for barley and oats.

¶ Same coefficients applied to all soy beans.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition. Fresh or Air-dry Substance. Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Composition. Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility. Fresh or Air-dry Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility. Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I. — GREEN FODDERS — *Con.*																			
(*c*) *Legumes* — Con.																			
Soy bean (medium green),	1	75	3.3	4.8	5.9	10.0	1.0	19.3	23.7	40.0	4.0	3.6	2.8	7.3	0.5	14.5	11.1	29.2	2.2
Soy bean (medium black),	2	75	3.1	4.7	5.9	10.0	1.3	18.9	23.4	39.9	5.2	3.5	2.8	7.3	0.7	14.2	10.1	29.1	2.8
Soy bean (late),	4	75	3.3	5.7	5.3	10.0	0.7	22.7	21.1	40.0	2.7	4.3	2.5	7.3	0.4	17.0	9.9	29.2	1.5
Alsike clover (*Trifolium hybridum*),	8	75	2.9	4.1	6.8	10.6	0.6	16.5	27.2	42.4	2.5	-	-	-	-	-	-	-	-
Crimson clover (*Trifolium incarnatum*),	2	75	3.5	3.9	7.5	9.5	0.6	15.8	29.8	38.1	2.4	3.0	4.2	7.0	0.4	12.2	16.7	28.2	1.6
Mammoth red clover (*Trifolium medium*),	4	75	2.4	3.8	7.2	11.1	0.5	15.4	28.7	44.2	2.1	-	-	-	-	-	-	-	-
Medium red clover (*Trifolium pratense*),	5	75	2.1	3.5	7.7	11.0	0.7	13.9	30.6	44.1	2.7	2.4	4.1	8.6	0.5	9.3	16.2	34.4	1.7
Sweet clover (*Melilotus alba*),	4	75	2.4	4.7	7.9	9.3	0.7	18.8	31.6	37.2	2.8	-	-	-	-	-	-	-	-
Sand lucern,	1	75	2.4	4.1	5.3	12.5	0.7	16.4	21.2	50.0	2.6	-	-	-	-	-	-	-	-
Cow-pea (*Vigna catjang*),	3	80	1.9	3.4	4.3	9.6	0.8	17.2	21.7	47.8	3.9	2.6	2.6	7.8	0.5	13.1	13.0	38.7	2.3
Canada beauty pea (*Pisum arvense*),	1	80	1.6	3.2	5.8	8.9	0.5	16.1	29.0	44.3	2.7	2.6	3.6	6.3	0.3	13.2	18.0	31.5	1.4*
Canada field pea (*Pisum arvense*),	1	80	1.8	3.9	6.3	7.5	0.5	19.7	31.6	37.2	2.7	3.2	3.9	5.3	0.3	16.2	19.6	26.4	1.4
English gray pea (*Pisum arvense*),	1	80	1.9	4.1	6.1	7.3	0.6	20.6	30.2	36.4	3.2	3.4	3.8	5.2	0.3	16.9	18.7	25.8	1.7

Prussian blue pea (*Pisum arvense*),	1	80	1.8	3.7	6.0	7.8	0.7	18.7	30.0	39.1	3.4	3.0	3.7	5.5	0.4	15.3	18.6	27.8	1.8
Flat pea (*Lathyrus sylvestris wagneri*),	2	80	1.8	5.8	4.9	6.6	0.9	29.0	24.8	32.9	4.3	-	-	-	-	-	-	-	-
Sainfoin (*Onobrychis sativa*),	1	75	2.1	4.4	6.0	11.6	0.9	17.4	24.0	46.5	3.5	-	-	-	-	-	-	-	-
Serradella (*Ornithopus sativus*),	3	80	2.1	2.9	5.9	8.7	0.4	14.4	29.5	43.3	2.2	-	-	-	-	-	-	-	-
Sulla (*Hedysarum coronarium*),	2	75	2.3	4.3	5.2	12.5	0.7	17.1	20.7	50.2	2.7	-	-	-	-	-	-	-	-
Scotch tares (*Vicia sativa*),	1	80	2.4	3.9	5.7	7.7	0.3	19.5	28.3	38.3	1.7	-	-	-	-	-	-	-	-
Spring vetch (*Vicia sativa*),	3	80	1.7	3.5	6.0	8.3	0.5	17.4	30.2	41.6	2.4	2.5	2.6	6.3	0.3	12.3	13.3	31.6	1.4
Hairy or sand vetch (*Vicia villosa*),	1	80	1.7	4.0	6.3	7.8	0.2	20.0	31.6	38.9	1.1	3.3	3.8	5.9	0.1	16.6	19.3	29.6	0.8
Kidney vetch (*Anthyllis vulneraria*),	1	80	2.7	3.7	3.1	9.8	0.7	18.4	15.3	48.9	3.7	-	-	-	-	-	-	-	-
(*d*) *Mixed and Miscellaneous.*																			
Barley and peas,	1	80	1.6	2.8	6.8	8.2	0.6	13.8	33.8	41.2	3.1	2.2	2.9	5.0	0.4	10.6	14.5	25.1	1.9
Barley and vetch,	2	80	1.2	2.8	6.5	9.0	0.5	13.8	32.4	45.2	2.3	-	-	-	-	-	-	-	-
Corn and soy bean,	1	80	1.3	2.7	4.3	11.2	0.5	13.8	21.3	56.1	2.4	-	-	-	-	-	-	-	-
Millet and peas,	1	80	1.8	2.4	7.5	8.0	0.3	12.0	37.5	39.9	1.5	-	-	-	-	-	-	-	-
Tall oat grass and alsike clover,	2	80	1.5	2.7	5.8	9.5	0.5	13.6	28.8	47.2	2.7	-	-	-	-	-	-	-	-
Orchard grass and alsike clover,	1	80	1.5	2.4	6.5	9.0	0.7	11.9	32.5	45.1	2.8	-	-	-	-	-	-	-	-
Peas and oats,	4	80	1.7	2.9	6.0	8.8	0.6	14.4	30.0	44.1	3.0	2.0	4.0	6.7	0.3	10.1	20.4	33.5	1.7
Vetch and oats (1-1),	3	80	1.8	3.0	6.3	8.4	0.5	15.1	31.4	42.1	2.7	2.3	4.3	5.7	0.2	11.3	21.4	28.6	1.3
Vetch and oats (1-4),	1	80	1.8	2.7	6.0	8.8	0.7	13.3	30.0	43.8	3.8	-	-	-	-	-	-	-	-
Wheat and vetch,	2	80	1.5	3.2	6.5	8.2	0.5	16.2	32.6	41.2	2.5	-	-	-	-	-	-	-	-
Apple pomace,	3	83	0.4	1.2	2.9	11.7	0.8	7.1	17.0	68.8	4.7	-	-	-	-	-	-	-	-

* Same coefficients applied to all Canada peas.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-Dry Substance.						Water-Free Substance.				Fresh or Air-Dry Substance.				Water-Free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I.—Green Fodders—*Con.*																			
(*d*) *Mixed and Miscellaneous*—Con.																			
Sugar beet pulp,	1	90	0.1	1.4	2.5	5.9	0.1	14.0	25.0	59.0	1.0	0.9	2.1	5.0	-	8.8	20.7	49.6	-
Cabbage waste,	1	82	4.9	3.6	2.6	6.6	0.3	19.7	14.3	36.8	1.9	-	-	-	-	-	-	-	-
Carrot tops,	1	80	2.8	4.2	2.7	9.9	0.4	21.2	13.6	49.3	2.0	-	-	-	-	-	-	-	-
Prickley comfrey (*Symphytum asperrimum*),	1	87	2.8	2.3	1.5	6.1	0.3	17.7	11.5	46.9	2.4	-	-	-	-	-	-	-	-
Purslane (*Portulaca oleracea*),	1	91	1.5	2.3	1.6	3.4	0.2	25.1	17.7	37.4	2.7	-	-	-	-	-	-	-	-
Dwarf Essex rape (*Brassica napus*),	1	85	2.4	1.9	2.9	7.2	0.6	12.9	19.3	47.8	4.3	1.7	2.5	6.6	0.3	11.5	16.8	43.9	2.1*
Summer rape (*Brassica napus*),	1	85	2.8	2.1	2.7	6.9	0.5	14.3	17.8	45.7	3.6	1.9	2.4	6.4	0.2	12.7	15.5	42.0	1.7
Winter rape (*Brassica napus*),	1	85	3.3	2.3	1.8	7.1	0.5	15.0	12.1	47.1	3.6	2.1	1.6	6.5	0.2	13.4	10.5	43.3	1.7
Sorghum (*Andropogon sorghum*),	6	80	1.4	1.8	5.4	11.0	0.4	8.8	27.0	55.3	1.8	-	-	-	-	-	-	-	-
Spurrey (*Spergula arvensis*),	1	72	2.6	2.9	7.0	15.4	0.1	10.3	25.0	55.0	0.4	-	-	-	-	-	-	-	-
Teosinte (*Euchlæna Mexicana*),	2	70	2.3	2.3	9.4	15.6	0.4	7.6	31.3	52.1	1.2	-	-	-	-	-	-	-	-

II. — SILAGE.																		
Apple pomace,	1	85	0.6	1.2	3.3	8.8	1.1	8.0	22.0	58.7	7.3	–	–	–	–	–	–	–	–
Corn,	45	80	1.1	1.7	5.4	11.1	0.7	8.5	26.8	55.7	3.5	1.0	3.8	8.4	0.6	4.8	18.8	42.3	2.9
Corn and soy bean,	4	76	2.4	2.5	7.2	11.1	0.8	10.4	30.0	46.3	3.3	1.6	4.7	8.3	0.7	6.8	19.5	34.7	2.7
Millet,	3	74	2.4	1.7	7.5	13.6	0.8	6.5	28.8	52.3	3.1	–	–	–	–	–	–	–	–
Millet and soy bean,	9	79	2.8	2.8	7.2	7.2	1.0	13.3	34.3	34.3	4.8	1.6	5.0	4.3	0.7	7.7	23.7	20.2	3.5
III. — HAY AND DRY COARSE FODDERS.																		
(a) *Meadow Grasses and Millets.*																		
Barnyard grass (*Panicum crus-galli*),	1	14	8.6	13.1	29.0	33.6	1.7	15.2	33.7	39.1	2.0	–	–	–	–	–	–	–	–
Barnyard millet (*Panicum crus-galli*),	7	14	7.3	8.2	28.0	40.9	1.6	9.5	32.5	47.6	1.9	5.3	17.4	21.3	0.7	6.1	20.2	24.8	0.9
Canada blue grass (*Poa compressa*),	1	14	4.8	5.9	31.3	42.1	0.9	6.9	36.4	48.9	2 2	–	–	–	–	–	–	–	–
Hungarian grass (*Chætochloa italica*),	3	14	6.3	8.4	24.6	45.0	1.7	9.8	28.6	52.3	2.0	5.0	16.7	30.2	1.1	5.9	19.4	35.0	1.3
Italian rye grass (*Lolium italicum*),	4	14	6.4	7.1	28.6	42.2	1.6	8.4	33.2	49.0	1.9	–	–	–	–	–	–	–	–
Kentucky blue grass (*Poa pratensis*),	3	14	6.4	7.7	30.5	39.7	1.7	8.9	35.5	46.1	2.0	4.4	19.2	21.0	0.7	5.1	22.4	24.4	0.9
Meadow fescue (*Festuca elatior pratensis*),	7	14	7.1	5.8	32.2	39.3	1.6	6.8	37.4	45.6	1.9	3.0	21.6	23.2	0.9	3.5	25.1	26.9	1.0
Orchard grass (*Dactylis glomerata*),	7	14	5.9	8.3	29.9	39.3	2.6	9.7	34.8	45.6	3.0	4.9	17.9	21.6	1.4	5.7	20.9	25.1	1.6
Perennial rye grass (*Lolium perenne*),	4	14	7.9	10.1	25.4	40.5	2.1	11.8	29.5	47.1	2.4	–	–	–	–	–	–	–	–
Red top (*Agrostis alba vulgaris*),	6	14	4.6	6.5	28.5	44.9	1.5	7.6	33.2	52.2	1.7	4.0	17.4	27.8	0.8	4.6	20.3	32.4	0.9
Red top (early cut),	1	14	4.3	5.8	30.9	43.3	1.7	6.8	35.9	50.3	2.0	3.5	18.9	26.9	0.9	4.1	21.9	31.2	1.0
Red top (late cut),	1	14	4.1	6.0	31.0	43.2	1.7	7.0	36.0	50.2	2.0	3.7	18.9	26.8	0.9	4.3	21.9	31.1	1.0
Tall oat grass (*Arrhenatherum elatius*),	4	14	4.6	6.4	30.9	42.1	1.9	7.4	36.0	49.0	2.2	3.3	17.0	24.4	1.1	3.8	19.8	28.4	1.2

* Same coefficients applied to all varieties of rape.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition. Fresh or Air-dry Substance. Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Composition. Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility. Fresh or Air-dry Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Digestibility. Water-free Substance. Protein.	Fibre.	Nitrogen-free Extract.	Fat.
III.—Hay and Dry Coarse Fodders — *Con.*																			
(*a*) *Meadow Grasses and Millets* — Con.																			
Timothy (*Phleum pratense*),	8	14	4.2	8.4	28.1	43.4	1.9	9.7	32.7	50.5	2.2	4.0	14.6	26.9	1.0	4.6	17.0	31.3	1.1
Timothy (early cut),	1	14	4.0	5.7	31.0	43.5	1.8	6.6	36.1	50.6	2.1	3.3	18.3	27.8	1.0	3.8	21.3	32.4	1.2
Timothy (late cut),	1	14	3.9	5.2	29.7	45.2	2.0	6.0	34.6	52.6	2.3	2.3	13.9	27.1	1.0	2.7	16.3	31.6	1.2
White top (*Agrostis vulgaris var*),	1	14	6.0	11.2	24.4	41.5	2.9	13.0	28.4	48.2	3.4	6.8	14.9	25.7	1.5	7.9	17.3	29.9	1.7
English hay (mixed grasses),	81	14	5.2	7.9	27.5	43.1	2.3	9.2	31.9	50.1	2.7	4.6	16.5	25.4	1.1	5.3	19.1	29.6	1.3
Canada hay,	4	14	4.6	6.1	28.1	45.1	2.1	7.1	32.7	52.4	2.4	-	-	-	-	-	-	-	-
Rowen,	20	14	6.1	10.9	23.6	42.3	3.1	12.7	27.4	49.2	3.6	7.5	15.8	27.9	1.5	8.8	18.4	32.5	1.7
Swamp or swale hay,	2	14	5.8	7.1	26.7	44.5	1.9	8.3	31.0	51.8	2.2	2.4	8.8	20.5	0.8	2.8	10.2	23.8	1.0
Fermented hay,	1	14	6.3	8.4	25.4	43.7	2.2	9.8	29.5	50.8	2.6	-	-	-	-	-	-	-	-
Black grass (*Juncus Gerardi*),	3	16	7.4	7.0	24.3	43.1	2.2	8.3	28.9	51.3	2.7	4.1	14.3	22.4	1.0	4.8	17.1	26.7	1.2
Branch grass (*Distichlis spicata*),	2	16	7.6	6.8	22.4	45.1	2.1	8.1	26.6	53.7	2.5	3.8	12.1	22.1	0.7	4.5	14.4	26.3	0.9
Flat sage (*Spartina stricta maritima var?*),	1	16	8.2	6.6	25.0	41.8	2.4	7.8	29.7	49.8	2.9	3.4	15.0	23.0	0.9	4.1	17.8	27.4	1.0

High grown salt hay (largely *Spartina patens*).	1	16	7.0	6.3	22.2	46.4	2.1	7.5	26.4	55.3	2.5	3.8	11.8	24.6	0.8	4.5	13.9	29.3	0.9
Fox grass (*Spartina patens*), ...	2	16	5.8	6.7	22.5	46.9	2.1	8.0	26.8	55.8	2.5	4.0	11.9	24.9	0.8	4.8	14.2	29.6	0.9
Cove mixture (black grass and red top), .	1	16	6.0	7.4	23.2	45.6	1.8	8.8	27.6	54.3	2.1	3.6	13.9	24.2	0.7	4.2	16.6	28.8	0.8
Mixed salt hay (largely fox grass and branch grass).	1	16	8.4	5.5	22.5	45.5	2.1	6.5	26.8	54.2	2.5	2.3	13.1	23.7	0.6	2.7	15.5	28.2	0.7
Salt hay (variety uncertain), ...	2	16	4.3	3.4	24.0	49.8	2.5	4.0	28.6	59.3	3.0	1.4	13.9	25.9	0.7	1.7	16.6	30.8	0.8
(b) Cereal Fodders.																			
Corn stover, from field, ...	41	40	3.9	4.6	20.6	30.1	0.8	7.6	34.2	50.2	1.4	1.7	13.2	17.5	0.5	2.7	21.9	29.1	1 0
Corn stover, very dry, ...	41	20	5.2	6.1	27.4	40.2	1.1	7.6	34.2	50.2	1.4	2.2	17.5	23.3	0.8	2.7	21.9	29.1	1.0
Oats, ...	6	15	6.9	11.7	25.5	38.3	2.6	13.8	30.0	45.0	3.1	6.8	12.8	13.4	1.6	8.0	15.0	15.8	2.0
(c) Legumes.																			
Alsike clover, ...	8	15	9.7	14.0	23.1	36.1	2.1	16.5	27.2	42.4	2.5	9.2	12.2	25.6	1.1	10.9	14.4	30.1	1.3
Mammoth red clover, ...	4	15	8.2	13.1	24.4	37.6	1.7	15.4	28.7	44.2	2.1	-	-	-	-	-	-	-	-
Medium red clover, ...	5	15	7.4	11.8	26.0	37.5	2.3	13.9	30.6	44.1	2.7	6.8	14.0	24.0	1.3	8.1	16.5	28.2	1.5
(d) Straw.																			
Barley, ...	2	15	4.8	6.5	32.2	39.0	2.5	7.7	37.9	45.9	2.9	-	-	-	-	-	-	-	-
Horse bean, ...	1	15	8.1	8.3	35.2	32.1	1.3	9.8	41.4	37.8	1.5	-	-	-	-	-	-	-	-
Soy bean, ...	3	15	6.1	4.7	36.1	36.3	1.8	5.5	42.5	42.7	2.1	-	-	-	-	-	-	-	-
Millet (*Chætochloa italica*), ...	1	15	5.3	3.6	35.2	39.5	1.4	4.2	41.4	46.5	1.7	-	-	-	-	-	-	-	-
Millet (*Panicum crus-galli*), ...	1	15	4.6	5.2	30.4	42.7	2.1	6.1	35.8	50.2	2.5	-	-	-	-	-	-	-	-
Millet (*Panicum miliaceum*), ...	1	15	5.2	3.3	35.9	38.1	2.5	3.9	42.2	44.8	3.0	-	-	-	-	-	-	-	-
Millet (variety uncertain), ...	1	15	5.8	4.2	35.5	38.3	1.2	4.9	41.8	45.1	1.4	-	-	-	-	-	-	-	-
Wheat, ...	1	15	4.1	6.2	30.5	42.8	1.4	7.3	35.9	50.4	1.6	-	-	-	-	-	-	-	-

A. *Composition and Digestibility of Fodder Articles* — Continued.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
III.—Hay and Dry Coarse Fodders —*Con.*																			
(e) *Mixed and Miscellaneous.*																			
Oat grass and alsike clover,	2	15	6.5	11.6	24.5	40.1	2.3	13.6	28.8	47.2	2.7	-	-	-	-	-	-	-	-
Orchard grass and alsike clover,	1	15	6.6	10.1	27.6	38.3	2.4	11.9	32.5	45.1	2.8	-	-	-	-	-	-	-	-
Peas and oats,	4	15	7.2	12.2	25.5	37.5	2.6	14.4	30.0	44.1	3.0	7.3	16.8	20.3	0.5	8.6	19.8	23.8	0.6
Vetch and oats (1-1),	3	15	7.4	12.8	26.7	35.8	2.3	15.1	31.4	42.1	2.7	7.7	17.6	19.3	0.4	9.1	20.7	22.7	0.5
Wheat and vetch,	2	15	6.4	13.8	27.7	35.0	2.1	16.2	32.6	41.2	2.5	-	-	-	-	-	-	-	-
White daisy,	1	15	6.0	6.6	30.7	39.7	2.0	7.8	36.1	46.7	2.4	-	-	-	-	-	-	-	-
Hairy lotus,	2	15	7.0	12.6	16.8	46.1	2.5	14.8	19.8	54.2	3.0	-	-	-	-	-	-	-	-
IV.—Vegetables, Fruits, etc.																			
Apples,	2	78	0.7	1.0	1.5	18.3	0.5	4.5	6.8	83.2	2.3	-	-	-	-	-	-	-	-
Artichokes,	1	78	1.1	2.9	0.9	16.9	0.2	13.1	4.1	76.9	0.9	-	-	-	-	-	-	-	-
Cabbages,	1	90	0.8	2.6	0.9	5.5	0.2	25.7	9.3	54.8	2.3	-	-	-	-	-	-	-	-
Beets, red,	7	88	1.1	1.5	0.7	8.6	0.1	12.5	5.8	71.7	0.8	-	-	-	-	-	-	-	-

Sugar beets,	13	86	0.9	1.6	0.9	10.5	0.1	11.0	6.7	75.1	0.7	1.5	0.9	10.5	0.05	10.0	6.7	75.1	0.4
Yellow fodder beets,	4	89	1.0	1.3	1.0	7.5	0.2	11.8	9.1	68.2	1.8	1.0	-	4.2	-	9.1	-	65.5	-
Mangolds,	5	88	1.2	1.4	0.8	8.5	0.1	11.7	6.7	70.8	0.8	1.0	0.3	7.7	-	8.8	2.9	64.4	-
Carrots,	5	89	0.9	1.0	1.1	7.8	0.2	9.1	10.0	70.9	1.8	-	-	-	-	-	-	-	-
Cranberries,	1	89	0.2	0.5	1.2	8.5	0.6	4.5	10.9	77.3	5.5	-	-	-	-	-	-	-	-
Parsnips,	1	80	1.5	1.3	1.5	15.0	0.7	6.5	7.5	75.0	3.5	-	-	-	-	-	-	-	-
Potatoes,	22	80	0.9	2.1	0.5	16.4	0.1	10.2	2.6	82.0	0.5	1.0	-	14.8	-	4.6	-	7.3	.07
Potatoes,	93	80	-	-	-	14.3*	-	-	-	71.5*	-	-	-	-	-	-	-	-	-
Japanese radish,	1	93	0.7	0.5	0.7	5.0	0.1	7.1	10.0	71.5	1.4	-	-	-	-	-	-	-	-
Turnips,	5	90	0.9	1.5	1.2	6.6	0.2	11.0	12.0	66.0	2.0	1.4	1.2	6.3	0.2	9.9	12.0	63.4	1.7
Ruta-bagas,	3	89	1.1	1.2	1.3	7.2	0.2	10.9	11.8	65.5	1.8	1.0	1.0	6.8	0.2	8.7	8.7	62.2	1.5
V. — CONCENTRATED FEEDS.																			
(a) Protein.																			
Cotton-seed meal,	129	7.0	6.5	45.1	6.1	24.2	11.1	48.5	6.6	26.0	11.9	39.7	3.4	14.8	9.4	42.7	3.6	15.9	11.1
Cotton-seed meal (low grade),	31	8.0	4.7	27.1	17.6	35.2	7.4	29.5	19.1	38.3	8.0	-	-	-	-	-	-	-	-
Cleveland flax meal,	19	9.0	5.3	38.3	8.8	36.2	2.4	42.1	9.7	39.8	2.6	32.4	7.0	31.1	2.3	35.8	7.8	34.2	2.5
Linseed meal (new process),	8	9.0	5.8	35.8	8.5	38.0	2.9	39.3	9.3	41.8	3.2	30.4	6.8	32.7	2.8	33.4	7.4	36.0	3.1
Linseed meal (old process),	55	8.5	5.2	35.3	8.5	36.5	6.0	38.6	9.2	39.9	6.6	31.4	4.9	28.5	5.3	34.4	5.2	31.1	5.9
Chicago gluten meal,	49	9.5	1.0	37.2	2.2	47.9	2.2	41.1	2.4	52.9	2.5	32.7	-	43.1	2.1	36.2	-	47.6	2.4
Cream gluten meal,	50	9.0	0.9	34.3	2.2	51.6	2.0	37.7	2.4	56.7	2.2	30.2	-	46.4	1.9	33.2	-	51.0	2.1
King gluten meal (new process),	3	9.0	-†	32.0	-†	-†	2.9	35.2	-	-	3.2	28.2	-	-	2.7	31.0	-	-	3.0

* Starch by inversion. † Not determined.

A. Composition and Digestibility of Fodder Articles — Continued.

NAME	Number of Analyses.	COMPOSITION.										DIGESTIBILITY.							
		FRESH OR AIR-DRY SUBSTANCE.						WATER-FREE SUBSTANCE.				FRESH OR AIR-DRY SUBSTANCE.				WATER-FREE SUBSTANCE.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V. — CONCENTRATED FEEDS — *Con.*																			
(*a*) *Protein* — Con.																			
King gluten meal (old process),	6	7.0	1.2	33.3	1.8	43.6	13.1	35.8	1.9	46.9	14.1	29.3	-	39.2	12.3	31.5	-	42.2	13.3
Buffalo gluten feed,	55	8.5	2.2	26.5	7.2	52.6	3.0	29.0	7.9	57.4	3.3	22.8	5.6	46.8	2.5	24.9	6.2	51.1	2.8
Davenport gluten feed,	2	8.5	1.9	26.2	6.3	53.8	3.3	28.6	6.9	58.8	3.6	22.5	4.9	47.9	2.8	24.6	5.4	52.3	3.0
Glen Cove gluten feed,	11	8.5	0.6	27.2	5.3	55.4	3.0	29.7	5.8	60.5	3.3	23.4	4.1	49.3	2.5	25.8	4.5	53.9	2.8
Golden gluten feed,	1	8.5	0.9	29.4	5.0	53.5	2.7	32.1	5.5	58.5	2.9	25.3	3.9	47.6	2.3	27.6	4.3	52.1	2.4
Marshalltown gluten feed,	3	8.5	-*	27.1	-*	-*	3.2	29.6	-	-	3.5	23.3	-	-	2.7	25.5	-	-	2.9
Bockford Diamond gluten feed,	15	8.5	1.1	25.2	7.1	54.9	3.2	27.5	7.8	60.0	3.5	21.7	5.5	48.9	2.7	23.7	6.1	53.4	2.9
Waukegan gluten feed,	13	8.5	1.1	26.5	7.7	52.8	3.4	29.0	8.4	57.7	3.7	22.8	6.0	47.0	2.9	24.9	6.6	51.4	3.1
Germ oil meal,	13	9.0	2.7	22.7	9.3	45.9	10.4	24.9	10.3	50.4	11.5	15.7	-	37.2	10.1	17.2	-	40.8	11.2
Dried brewers' grains,	5	8.0	3.8	23.1	10.8	49.4	4.9	25.1	11.7	53.7	5.4	18.3	5.7	28.6	4.5	19.8	6.2	31.2	4.9
Wet brewers' grains,	1	77.0	0.7	6.7	3.8	9.8	2.0	29.0	16.7	42.5	8.5	5.3	2.0	5.7	1.8	22.9	8.9	24.7	7.7
Dried distillers' grains (average different brands).†	5	8.0	2.0	27.3	11.1	42.2	9.4	29.7	12.1	45.8	10.2	20.2	-	34.6	8.8	22.0	-	37.6	9.6

Atlas gluten meal,	9	8.0	1.7	31.4	10.9	35.5	12.5	34.1	11.9	38.6	13.6	23.2	-	29.1	11.8	25.2	-	31.7	12.8
Malt sprouts,	2	11.0	5.2	24.6	13.0	43.6	2.6	27.6	14.6	49.0	3.0	19.7	4.3	29.7	2.6	22.1	4.8	33.3	3.0
Wheat middlings (fine and flour),	50	10.0	3.2	18.8	3.2	60.1	4.7	20.9	3.6	66.7	5.2	16.0	1.2	52.9	4.0	17.8	1.3	58.7	4.4
Wheat middlings (coarse, so-called standard).	177	10.0	4.3	17.8	7.0	55.8	5.1	19.8	7.8	61.9	5.7	14.2	2.3	45.2	4.4	15.8	2.6	50.1	4.9
Mixed feed,	368	10.0	5.4	16.8	8.6	54.5	4.7	18.7	9.5	60.6	5.2	-	-	-	-	-	-	-	-
Mixed feed (low grade),	6	9.0	4.3	12.1	16.1	55.4	3.1	13.3	17.7	60.9	3.4	-	-	-	-	-	-	-	-
Wheat bran,	209	10.0	6.4	16.0	10.0	53.0	4.6	17.8	11.1	58.9	5.1	12.5	2.9	36.6	3.1	13.9	3.2	40.6	3.5
Wheat bran (spring),	4	10.0	5.8	16.1	10.5	52.6	5.0	17.9	11.7	58.4	5.6	-	-	-	-	-	-	-	-
Wheat bran (winter),	3	10.0	6.2	15.3	8.6	57.0	2.9	17.0	9.6	63.3	3.2	-	-	-	-	-	-	-	-
H-O dairy feed,	10	8.0	3.6	18.0	13.0	53.3	4.1	19.6	14.1	57.9	4.5	14.0	5.3	37.3	3.5	15.3	5.8	40.5	3.8
Buckwheat feed,	1	9.0	5.0	32.3	7.5	37.7	8.5	35.5	8.2	41.4	9.4	-	-	-	-	-	-	-	-
Buckwheat middlings,	1	11.0	4.8	22.7	4.6	50.2	6.7	25.5	5.2	56.4	7.5	-	-	-	-	-	-	-	-
Cocoanut meal,	2	8.0	3.7	20.0	12.0	39.4	16.3	22.4	13.1	42.8	17.7	-	-	-	-	-	-	-	-
Gluten flour,	1	9.0	0.7	38.4	0.2	50.8	0.9	42.2	0.2	55.8	1.0	-	-	-	-	-	-	-	-
Atlantic gluten meal,	1	7.0	1.2	41.1	1.5	46.9	2.3	44.2	1.6	50.4	2.5	-	-	-	-	-	-	-	-
Proteina,	4	8.0	2.5	21.8	10.0	51.1	6.6	23.7	10.9	55.5	7.2	-	-	-	-	-	-	-	-
Sucrene dairy feed,	6	9.0	6.6	16.8	11.7	52.8	3.1	18.4	12.9	58.0	3.4	-	-	-	-	-	-	-	-
Sucrene oil meal,	3	9.0	5.7	23.2	10.7	48.6	2.8	25.5	11.7	53.4	3.1	-	-	-	-	-	-	-	-
Horse beans,	1	14.0	3.8	25.8	7.0	48.6	0.8	30.0	8.1	56.5	1.0	-	-	-	-	-	-	-	-
Red adzinki beans,	2	14.0	3.6	21.0	4.0	56.7	0.7	24.4	4.7	65.9	0.8	-	-	-	-	-	-	-	-
Saddle beans,	1	14.0	5.3	13.0	4.1	49.4	14.2	15.1	4.8	57.4	16.5	-	-	-	-	-	-	-	-

* Not determined.

† See thirteenth report, p. 44.

A. Composition and Digestibility of Fodder Articles — Continued.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-Dry Substance.						Water-Free Substance.				Fresh or Air-Dry Substance.				Water-Free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V.—Concentrated Feeds—*Con.*																			
(a) *Protein*—Con.																			
Soy beans (variety uncertain),	4	14.0	5.1	30.8	4.9	28.2	17.0	35.8	5.7	32.8	19.8	-	-	-	-	-	-	-	-
Soy bean meal,	1	14.0	4.7	32.9	3.7	29.2	15.5	38.3	4.3	33.9	18.0	29.6	1.9	21.0	13.2	34.5	2.2	24.4	15.3
Ground flax seed,	2	7.0	3.5	23.5	5.5	23.3	37.2	25.3	5.9	25.0	40.0	-	-	-	-	-	-	-	-
Pea meal,	1	10.0	2.6	18.9	17.5	49.4	1.6	21.0	19.4	54.9	1.8	15.7	4.6	46.4	0.9	17.4	5.0	51.6	1.0
Peanut meal,	1	8.0	4.0	49.0	3.5	24.7	10.8	53.3	3.8	26.8	11.8	44.6	0.8	22.7	9.6	48.5	0.9	24.7	10.5
(b) *Starchy.*																			
Barley kernels,	1	11.0	2.7	10.3	5.5	68.6	1.9	11.6	6.2	77.1	2.1	-	-	-	-	-	-	-	-
Ground barley,	5	13.0	2.3	11.3	5.7	65.8	1.9	13.0	6.5	75.6	2.2	7.9	2.9	60.5	1.7	9.1	3.3	69.6	2.0
Broom-corn seed,	1	14.0	2.2	9.6	7.1	63.6	3.5	11.2	8.3	73.9	4.0	-	-	-	-	-	-	-	-
Broom-corn meal,	1	14.0	2.0	9.6	6.9	64.0	3.5	11.2	8.0	74.3	4.1	-	-	-	-	-	-	-	-
Buckwheat kernels,	1	12.0	1.9	9.9	10.3	63.5	2.4	11.3	11.7	72.1	2.7	-	-	-	-	-	-	-	-
Corn kernels,	32	11.0	1.4	10.8	1.9	70.2	4.7	12.1	2.1	78.9	5.3	-	-	-	-	-	-	-	-
Corn meal,	56	14.0	1.4	9.5	1.9	69.9	3.3	11.0	2.2	81.3	3.9	6.5	-	66.4	3.0	7.5	-	77.2	3.6

Sweet corn kernels,	3	11.0	1.9	12.5	2.4	64.9	7.3	14.0	2.7	72.9	8.2	-	-	-	-	-	-	-	-
Corn and cob meal,	37	11.0	1.4	8.9	6.7	68.4	3.6	10.0	7.5	76.8	4.1	5.0	3.1	60.2	3.0	5.6	3.1	67.6	3.4
Barnyard millet seed,	1	11.0	3.3	12.2	7.6	60.3	5.6	13.7	8.6	67.7	6.3	-	-	-	-	-	-	-	-
Millet seed (variety uncertain),	4	12.0	2.6	11.1	7.7	62.9	3.7	12.5	8.8	71.5	4.2	-	-	-	-	-	-	-	-
Oat kernels,	5	11.0	2.9	12.9	8.5	59.6	5.1	14.5	9.6	66.9	5.7	11.1	2.6	47.1	4.2	12.5	3.0	52.9	4.7*
Ground oats,	3	12.0	3.3	11.4	8.7	60.8	3.8	13.0	9.9	69.1	4.3	8.9	1.7	46.2	3.2	10.1	2.0	52.5	3.6†
Wheat kernels,	7	11.0	1.8	12.4	2.3	70.8	1.7	13.9	2.6	79.6	1.9	-	-	-	-	-	-	-	-
Ground wheat,	1	12.0	1.9	12.1	2.9	69.2	1.9	13.7	3.3	78.6	2.2	-	-	-	-	-	-	-	-
Bakery refuse,	1	13.0	10.1	8.0	0.3	63.0	5.6	9.2	0.4	72.4	6.4	-	-	-	-	-	-	-	-
Cassava starch refuse,	1	12.0	1.6	0.8	6.1	78.8	0.7	0.9	6.9	89.6	0.8	-	-	-	-	-	-	-	-
Cerealine,	4	11.0	2.6	11.1	4.9	62.7	7.7	12.5	5.5	70.5	8.6	8.9	4.0	59.6	6.2	10.0	4.5	67.0	7.0
Cocoa dust,	1	7.0	6.3	14.4	5.5	42.7	24.1	15.5	5.9	45.9	25.9	-	-	-	-	-	-	-	-
Cocoa shells,	1	5.0	8.4	18.0	15.9	50.9	1.8	18.9	16.7	53.6	1.9	-	-	-	-	-	-	-	-
Cocoanut meat,	1	1.0	0.8	9.9	7.5	15.3	65.5	10.0	7.5	15.1	66.1	-	-	-	-	-	-	-	-
Chop feed,	3	11.0	0.8	10.2	12.7	60.1	5.2	11.5	14.3	67.5	5.8	6.8	7.9	50.5	4.3	7.7	8.9	56.7	4.8
Corn bran,	2	11.0	2.0	10.8	12.4	59.8	4.0	12.1	13.9	67.2	4.5	-	-	-	-	-	-	-	-
Corn cobs,	6	8.0	1.3	2.7	31.3	56.2	0.5	2.9	34.0	61.1	0.6	0.5	17.8	27.0	-	0.6	19.4	29.3	-
Corn screenings,	1	11.0	2.1	7.4	2.9	72.6	4.0	8.3	3.3	81.5	4.5	-	-	-	-	-	-	-	-
Corn and oat feed,	47	10.0	3.0	9.1	10.0	64.7	3.2	10.1	11.1	71.9	3.6	6.5	4.8	53.7	2.8	7.2	5.3	59.7	3.1
Corn, oat, and barley feed,	8	10.0	3.1	11.4	8.3	62.4	4.8	12.7	9.2	69.3	5.3	-	-	-	-	-	-	-	-
Cotton hulls,	5	11.0	2.6	5.3	39.7	39.0	2.4	6.0	44.6	43.8	2.7	-	15.9	16.0	2.1	-	17.8	18.0	2.3
Cotton-hull bran,	1	11.0	1.9	2.3	35.0	48.7	1.1	2.6	39.3	54.7	1.2	-	-	-	-	-	-	-	-

* Horses. † Ruminants.

A. Composition and Digestibility of Fodder Articles — Concluded.

Name.	Number of Analyses.	Composition.										Digestibility.							
		Fresh or Air-dry Substance.						Water-free Substance.				Fresh or Air-dry Substance.				Water-free Substance.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V.—Concentrated Feeds—*Con.*																			
(*b*) *Starchy*—Con.																			
Cotton-seed feed,	4	11.0	3.1	10.5	36.0	35.9	3.5	11.8	40.5	40.3	3.9	5.4	16.6	19.8	3.0	6.0	18.6	22.2	3.4
Flax-seed screenings,	1	7.0	5.4	15.7	16.5	44.5	10.9	16.9	17.8	47.8	11.7	-	-	-	-	-	-	-	-
Hominy meal,	28	9.0	2.6	11.2	4.4	64.5	8.3	12.3	4.8	70.9	9.1	-	-	-	-	-	-	-	-
H-O horse feed,	12	9.0	3.1	12.6	9.8	62.0	3.5	13.8	10.8	68.1	3.9	9.3	3.4	49.0	2.9	10.2	3.8	53.8	3.0
Maizeline,	1	5.0	2.7	10.0	7.9	66.0	8.4	10.5	8.3	69.5	8.9	-	-	-	-	-	-	-	-
Mellin's Food refuse,	1	7.0	3.9	11.4	7.1	67.2	3.4	12.3	7.6	72.2	3.7	-	-	-	-	-	-	-	-
Canada oat feed,	2	7.0	5.4	13.2	24.8	44.7	4.9	14.2	26.7	48.1	5.3	-	-	-	-	-	-	-	-
Oat feed (average quality),	86	7.0	5.2	8.2	20.9	55.7	3.0	8.8	22.5	59.9	3.2	6.6	9.0	37.3	2.7	7.1	9.7	40.1	2.8
Oat feed (low grade),	2	7.0	4.6	2.7	30.2	54.4	1.0	2.9	32.5	58.5	1.1	1.7	9.7	18.0	0.9	1.8	10.4	19.3	1.0
Oat meal,	1	9.0	1.9	16.8	1.1	64.5	6.7	18.4	1.2	70.9	7.4	-	-	-	-	-	-	-	-
Oat middlings,	1	11.0	4.2	10.8	17.4	53.3	3.3	12.1	19.5	59.9	3.7	-	-	-	-	-	-	-	-
Parson's "Six-dollar" feed,	1	11.0	7.9	10.0	17.9	51.1	2.1	11.2	20.1	57.4	2.4	-	-	-	-	-	-	-	-

Pea bran,	2	11.0	2.7	10.0	39.7	35.6	1.0	11.3	44.5	40.0	1.2	-	-	-	-	-	-	-	-
Peanut feed,	2	10.0	2.6	8.9	56.4	16.6	5.5	9.9	62.7	18.4	6.1	6.3	6.2	8.1	5.0	7.0	6.9	9.0	5.5
Peanut husks,	1	13.0	1.2	5.0	66.0	13.1	1.7	5.7	75.9	15.1	1.9	-	-	-	-	-	-	-	-
Quaker dairy feed,	32	8.0	4.6	13.2	16.8	54.3	3.1	14.3	18.3	59.0	3.4	10.7	7.2	36.4	2.8	11.6	7.9	39.5	3.0
Louisiana rice bran,	1	11.0	9.4	8.7	13.3	49.0	8.6	9.8	14.9	55.0	9.7	-	-	-	-	-	-	-	-
Rice meal,	2	11.0	8.2	11.8	5.3	50.8	12.9	13.2	6.0	57.0	14.6	7.3	-	46.7	11.7	8.2	-	52.4	13.3
Rye bran,	2	11.0	4.1	15.6	3.5	63.5	2.3	17.8	4.0	71.3	2.6	-	-	-	-	-	-	-	-
Rye feed,	3	11.0	2.7	13.1	3.2	67.4	2.6	14.7	3.6	75.7	2.9	10.5	-	59.3	2.3	11.8	-	66.6	2.6
Rye middlings,	1	11.0	3.6	11.7	3.3	65.4	5.0	13.2	3.7	73.5	5.6	-	-	-	-	-	-	-	-
Schumacher's stock food,	14	8.0	4.0	11.3	11.8	60.3	4.6	12.3	12.8	65.5	5.0	-	-	-	-	-	-	-	-
Stalk, corn, and cob feed,	1	10.0	2.7	7.5	17.2	60.5	2.1	8.3	19.2	67.2	2.3	-	-	-	-	-	-	-	-
Starch *refuse*,	2	12.0	1.8	4.8	3.8	76.3	1.3	5.4	4.3	86.7	1.5	-	-	-	-	-	-	-	-
Sucrene chop feed,	1	9.0	6.4	11.4	13.9	56.9	2.4	12.5	15.3	62.5	2.7	-	-	-	-	-	-	-	-
Victor corn and oat feed,	39	10.0	3.5	8.6	11.3	62.9	3.7	9.6	12.6	69.9	4.1	6.1	5.4	52.2	3.2	6.8	6.1	58.0	3.6
Wheat flour,	2	12.0	0.4	9.9	0.1	76.8	0.8	11.2	0.1	87.3	0.9	-	-	-	-	-	-	-	-
(c) *Poultry.*																			
American poultry food,	14	8.0	2.9	13.1	6.5	63.6	5.9	14.2	7.1	69.1	6.4	-	-	-	-	-	-	-	-
Cut bone,	1	26.0	21.5	20.7	-	0.2	31.6	28.0	-	0.3	42.6	-	-	-	-	-	-	-	-
Raw ground bone,	1	8.0	64.4	23.9	-	3.4	0.3	26.0	-	3.7	0.3	-	-	-	-	-	-	-	-
Cut clover,	2	10.0	6.8	17.9	20.5	41.8	3.0	19.9	22.8	46.4	3.4	-	-	-	-	-	-	-	-
H-O poultry food,	3	9.0	2.7	17.4	4.4	60.2	5.3	19.1	5.9	66.2	5.8	-	-	-	-	-	-	-	-
Meat and bone meal,	26	6.0	37.5	40.6	-	7.5	10.2	43.1	-	8.0	10.9	-	-	-	-	-	-	-	-
Meat scrap,	4	9.0	15.3	49.5	-	5.0	21.2	54.4	-	5.5	23.2	-	-	-	-	-	-	-	-

B. Fertilizer Ingredients of Fodder Articles.*

[Figures equal percentages or pounds in 100.]

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I.—Green Fodders.					
(a) Meadow Grasses and Millets.					
Hungarian grass,	1	75	0.38	0.52	0.15
Japanese millet,	3	80	0.33	0.22	0.10
Barnyard millet,	3	80	0.30	0.67	0.10
Millet,	1	80	0.29	0.43	0.11
Orchard grass,	4	70	0.43	0.56	0.13
(b) Cereal Fodders.					
Corn fodder,	21	80	0.39†	0.27	0.13
Oats,	3	75	0.72	0.56	0.19
Rye,	2	75	0.27	0.57	0.11
(c) Legumes.					
Alfalfa,	4	75	0.55	0.39	0.14
Horse bean,	1	85	0.41	0.21	0.05
Soy bean,	1	75	–	0.49	0.14
Soy bean (early white),	1	75	0.71	0.69	0.16
Soy bean (medium green),	1	75	0.70	0.59	0.17
Soy bean (medium black),	1	75	0.88	0.62	0.20
Soy bean (late),	1	75	0.75	0.85	0.18
Alsike clover,	6	75	0.66	0.62	0.19
Mammoth red clover,	3	75	0.63	0.34‡	0.15
Medium red clover,	2	75	0.59	0.62	0.12
Sweet clover,	1	75	0.54	0.50	0.15
White lupine,	1	85	0.45	0.26	0.05
Yellow lupine,	1	85	0.40	0.44	0.09
Cow-pea,	1	80	0.36	0.20	0.11
Flat pea,	1	80	1.00	0.43	0.13
Small pea,	1	80	0.53	0.41	0.12
Sainfoin,	1	75	0.68	0.57	0.20
Serradella,	2	80	0.48	0.49	0.16

* Most of these analyses were made in earlier years by the Massachusetts State Experiment Station. The percentages of the several ingredients will vary considerably, depending upon the fertility of the soil, and especially upon the stage of growth of the plant. In the majority of cases the number of samples analyzed is too few to give a fair average. The figures, therefore, must be regarded as close approximations, rather than as representing absolutely the exact fertilizing ingredients of the different materials. (J. B. L.)

† Too high; 0.26 nearer correct. ‡ Evidently below normal.

B. Fertilizer Ingredients of Fodder Articles — Continued.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I. — GREEN FODDERS — *Con.*					
(*c*) *Legumes* — Con.					
Sulla,	2	75	0.68	0.58	0.12
Spring vetch,	1	80	0.48	0.60	0.13
Kidney vetch,	1	80	0.59	0.37	0.10
(*d*) *Mixed and Miscellaneous.*					
Vetch and oats,	4	80	0.30*	0.30	0.14
Apple pomace,	2	83	0.21	0.12	0.02
Common buckwheat,	1	85	0.44	0.54	0.09
Japanese buckwheat,	1	85	0.26	0.53	0.14
Silver hull buckwheat,	1	85	0.29	0.39	0.14
Carrot tops,	1	80	0.69	1.08	0.13
Prickly comfrey,	1	87	0.37	0.76	0.12
Summer rape,	1	85	0.34	0.78	0.10
Sorghum,	7	80	0.27	0.27	0.11
Teosinte,	1	70	0.47	1.18	0.06
II. — SILAGE.					
Corn,	7	80	0.42	0.39	0.13
Corn and soy bean,	1	76	0.65	0.36	0.35
Millet,	3	74	0.26	0.62	0.14
Millet and soy bean,	5	79	0.42	0.44	0.11
III. — HAY AND DRY COARSE FODDERS.					
(*a*) *Meadow Grasses and Millets.*					
Barnyard millet,	3	14	1.29	2.88	0.43
Hungarian grass,	1	14	1.29	1.79	0.52
Italian rye grass,	4	14	1.12	1.19	0.53
Kentucky blue grass,	2	14	1.20	1.54	0.39
Meadow fescue,	6	14	0.93	1.98	0.37
Orchard grass,	4	14	1.23	1.60	0.38
Perennial rye grass,	2	14	1.16	1.47	0.53
Red top,	4	14	1.07	0.95	0.33
Timothy,	3	14	1.20	1.42	0.33
English hay (mixed grasses),	12	14	1.29	1.52	0.29
Rowen,	13	14	1.72	1.58	0.48
Branch grass,	1	16	1.06	0.87	0.19
Fox grass,	1	16	1.18	0.95	0.18
Salt hay (variety uncertain),	1	16	1.05	0.64	0.23

* Too low; 0.43 nearer correct.

B. Fertilizer Ingredients of Fodder Articles — Continued.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
III.—HAY AND DRY COARSE FODDERS — *Con.*					
(*b*) *Cereal Fodders.*					
Corn stover, from field,	17	40	0.69	0.92	0.20
Corn stover, very dry,	17	20	0.92	1.22	0.26
Oats,	3	15	2.45*	1.90	0.65
(*c*) *Legumes.*					
Alsike clover,	6	15	2.26	2.10	0.63
Mammoth red clover,	3	15	2.14	1.16†	0.52
Medium red clover,	2	15	2.01	2.11	0.41
(*d*) *Straw.*					
Barley,	2	15	0.95	2.03	0.19
Soy bean,	1	15	0.69	1.04	0.25
Millet,	1	15	0.68	1.73	0.18
(*e*) *Mixed and Miscellaneous.*					
Vetch and oats,	4	15	1.29‡	1.27	0.60
Broom corn waste (stalks),	1	10	0.87	1.87	0.47
Palmetto root,	1	12	0.54	1.37	0.16
Spanish moss,	1	15	0.61	0.56	0.07
White daisy,	1	15	0.26	1.18	0.41
IV.—VEGETABLES, FRUITS, ETC.					
Apples,	2	78	0.12	0.17	0.01
Artichokes,	1	78	0.46	0.48	0.17
Beets, red,	8	88	0.24	0.44	0.09
Sugar beets,	4	86	0.24	0.52	0.11
Yellow fodder beets,	1	89	0.23	0.56	0.11
Mangolds,	3	88	0.15	0.34	0.14
Carrots,	3	89	0.16	0.46	0.09
Cranberries,	1	89	0.08	0.10	0.03
Parsnips,	1	80	0.22	0.62	0.19
Potatoes,	5	80	0.29	0.51	0.08
Japanese radish,	1	93	0.08	0.40	0.05
Turnips,	4	90	0.17	0.38	0.12
Ruta-bagas,	3	89	0.19	0.49	0.12

* Too high; 1.90 nearer correct. † Evidently below normal.
‡ Too low; 1.80 nearer correct.

B. Fertilizer Ingredients of Fodder Articles — Continued.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
V.—CONCENTRATED FEEDS.					
(a) Protein.					
Cotton-seed meal,	24	7.0	7.22	1.85	2.50
Linseed meal (new process),	5	9.0	5.77	1.24	1.68
Linseed meal (old process),	4	8.5	5.36	1.20	1.77
Chicago gluten meal,	2	9.5	6.05	0.06	0.43
King gluten meal,	1	7.0	5.74	0.08	0.70
Gluten meal (brand uncertain),	5	8.5	5.09	0.05	0.42
Buffalo gluten feed,	5	8.5	4.24	0.06	0.34
Dried brewers' grains,	2	8.0	3.68	0.86	1.06
Atlas gluten meal,	1	8.0	4.97	0.17	0.24
Wheat middlings,	2	10.0	2.79	0.76	1.27
Wheat bran,	10	10.0	2.36	1.40	2.10
Proteina,	1	8.0	3.04	0.58	1.02
Red adzinki bean,	1	14.0	3.27	1.55	0.95
White adzinki bean,	1	14.0	3.45	1.53	1.00
Saddle bean,	1	14.0	2.08	2.09	1.49
Soy bean (variety uncertain),	2	14.0	5.58	2.10	1.97
Soy bean meal,	1	14.0	5.68	2.15	1.51
Pea meal,	1	10.0	3.04	0.98	1.81
Peanut meal,	1	8.0	7.84	1.54	1.27
(b) Starchy.					
Ground barley,	1	13.0	1.56	0.34	0.66
Corn kernels,	13	11.0	1.82	0.40	0.70
Corn meal,	3	14.0	1.92	0.34	0.71
Corn and cob meal,	29	11.0	1.38	0.46	0.56
Common millet seed,	2	12.0	2.00	0.45	0.95
Japanese millet seed,	1	12.0	1.58	0.35	0.63
Oat kernels,	1	11.0	2.05	-	-
Buckwheat hulls,	1	12.0	0.49	0.52	0.07
Cocoa dust,	1	7.0	2.30	0.63	1.34
Corn cobs,	8	8.0	0.52	0.63	0.06
Cotton hulls,	3	11.0	0.75	1.08	0.18
Oat feed,	1	7.0	1.46	0.72	0.60
Peanut feed,	2	10.0	1.46	0.79	0.23

B. Fertilizer Ingredients of Fodder Articles — Concluded.

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
V. — CONCENTRATED FEEDS — *Con.*					
(*b*) *Starchy* — Con.					
Peanut husks,	1	13.0	0.80	0.48	0.13
Louisiana rice bran,	1	11.0	1.42	0.83	1.70
Rye feed,	1	11.0	1.92	0.97	1.54
Rye middlings,	1	11.0	1.87	0.82	1.28
Schumacher's stock feed,	1	8.0	1.80	0.63	0.53
Victor corn and oat feed,	2	10.0	1.38	0.61	0.59
Damaged wheat,	1	13.0	2.26	0.51	0.83
Wheat flour,	2	12.0	2.02	0.36	0.35
(*c*) *Poultry.*					
American poultry food,	1	8.0	2.22	0.52	0.98
Wheat meal,	1	8.0	11.21	0.30	0.73
VI. — DAIRY PRODUCTS.					
Whole milk,	297	86.4	0.57	0.19*	0.16*
Human milk,	3	88.1	0.24	-	-
Skim-milk,	22	90.3	0.59	0.18†	0.20†
Buttermilk,	1	91.1	0.51	0.05	0.04
Whey,	1	93.7	0.10	0.07	0.17
Butter,	117	12.5	0.19	-	-

* From Farrington and Woll. † From Woll's handbook.

C. Analyses of Dairy Products.

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Solids.			Fat.			Curd (N. × 6.25).	Salt.	Ash.
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.			
Whole milk,	3,281	19.55	10.02	13.57	10.70	1.50	4.32	3.54*	-	0.73†
Human milk,	3	13.59	10.50	11.87	3.77	1.66	2.52	1.48	-	0.24
Colostrum,	2	24.75	21.25	23.00	3.00	3.00	3.00	2.84‡	-	1.00
Skim-milk (largely from Cooley process),	358	10.48	7.68	9.20	1.80	0.05	0.32	-	-	-
Buttermilk,	31	9.86	6.83	8.33	0.38	0.11	0.27	-	-	-
Cream (from Cooley process),	203	32.78	18.12	26.10	25.00	10.53	17.60	-	-	-
Butter (salted),	117	94.84	83.41	87.56	89.33	77.95	83.31	1.17§	3.17§	-
Butter (fresh),	14	85.36	72.49	82.24	85.05	72.21	81.48	0.76	-	-
Whole-milk cheese,	2	-	-	63.51	-	-	35.83	24.41	-	3.27
Cheese from partially skimmed milk,	2	-	-	60.23	-	-	25.62	31.18	-	3.44
Skim-milk cheese,	2	-	-	55.32	-	-	16.72	34.09	-	4.51
Cheese from skim-milk, with addition of buttermilk,	1	-	-	51.62	-	-	18.35	28.63	-	4.65
Genuine oleomargarine cheese,	1	-	-	62.10	-	-	31.66	25.94	-	4.50

* Average of 297 analyses. † Average of 253 analyses. ‡ Nitrogen. § Average of 115 analyses.

D. Coefficients of Digestibility of American Feed Stuffs. — Experiments made in the United States.

COMPILED BY J. B. LINDSEY, ASSISTED BY NATHAN J. HUNTING.

Experiments with Ruminants.
Experiments with Swine.
Experiments with Horses.
Experiments with Poultry.

Dec. 31, 1901.

Experiments with Ruminants.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I.—Green Fodders.									
(a) *Meadow Grasses and Millets.*									
Barnyard millet in blossom (Mass.),	3	6	67—76 70	- -	45—67 56	58—70 65	71—77 73	65—77 71	54—67 58
Japanese millet, bloom, to early seed (Storrs),	2	3	- -	62—66 64	52—58 55	45—57 50	59—63 62	64—68 67	60—72 68
Hungarian grass, early to late bloom,	3	8	61—71 66	61—74 68	- -	59—72 63	65—76 70	64—71 67	48—85 62
Grass, meadow, young,	1	1	69	-	-	65	74	72	55
Grass, meadow, young, and dried,	1	1	71	-	-	71	77	73	60
Grass, timothy,	1	3	63—65 64	- -	31—33 32	48—48 48	54—53 56	65—67 66	52—54 52
Grass, timothy rowen,	1	2	- -	65—67 66	- -	72—72 72	60—68 64	67—68 68	51—55 52
(b) *Cereal Fodders.*									
Corn fodder, dent, immature,	4	11	64—74 68	- -	- -	56—80 66	60—76 67	64—79 71	37—83 68
Corn fodder, dent, milk,	3	9	70	-	-	61	64	76	78
Corn fodder, dent, mature,	7	13	66	-	-	53	52	74	76
Corn fodder, dent, mature, B. & W., coarse,	1	2	51—54 52	- -	- -	20—28 24	46—47 46	57—61 59	74—82 78

Corn fodder, sweet, milk stage,	1	2	77—78 77	- -	- -	77—78 77	74—76 75	80—81 81	73—74 74
Corn fodder, sweet, roasting stage,	9	12	- -	67—79 72	22—61 48	52—69 62	54—72 60	73—82 77	62—82 74
Sorghum, blossom,	1	2	73—73 73	- -	- -	51—56 53	74—75 75	78—78 78	81—82 81
Sorghum, Early Amber, past blossom,	1	2	61—62 61	- -	- -	38—42 40	42—45 42	70—71 71	- 67
Sorghum, average both samples,	2	4	67	-	-	46	59	74	74
Barley fodder, bloom,	2	4	- -	62—71 67	- -	69—73 72	49—66 61	69—76 71	56—63 60
Barley fodder, seeds forming,	2	2	- -	66—71 68	40—44 42	67—71 69	47—65 56	- 74	48—50 49
Oat fodder, bloom (?),	1	2	- -	63—65 64	- -	75—76 75	58—63 60	63—63 63	68—71 70
Oat fodder, early seed,	2	3	- -	56—63 60	49—68 60	68—73 71	43—56 51	60—67 62	67—72 69
Rye fodder, heading,	1	2	73—74 74	- -	- -	79—80 79	80—80 80	70—71 71	74—74 74
(c) Legumes.									
Clover, red, late blossom,	1	2	65—67 66	- -	- -	66—68 67	52—53 53	76—79 78	63—66 65
Clover, rowen, late blossom,	1	2	- -	60—62 61	- -	61—62 62	51—54 52	64—68 65	60—61 61
Clover, crimson, late blossom,	1	3	- -	68—70 69	- -	77—77 77	54—58 56	74—75 74	63—69 66
Clover, average three samples,	3	7	-	-	-	70	54	72	64
Cow-peas, ready for soiling,	2	4	66—77 68	72—76 74	19—28 23	73—77 76	57—62 60	76—84 81	56—62 59

Experiments with Ruminants — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I.—GREEN FODDERS—*Con.*									
(c) *Legumes*—Con.									
Canada field peas, before bloom,	1	2	68	71—72 71	- -	81—83 82	62—62 62	71—71 71	50—55 52
Canada field peas, bloom to seed,	1	3	60—65 63	- -	40—45 43	79—80 80	40—52 46	72—75 74	45—53 49
Soy beans, variety uncertain, before bloom,	1	2	- -	64—67 66	- -	77—80 79	45—55 50	71—73 72	50—58 54
Soy beans, variety uncertain, seeding,	1	2	- -	61—63 62	- -	68—71 69	38—43 41	72—75 73	49—59 54
Soy beans, medium green, full bloom,	1	2	- -	62—63 63	22—28 25	76—78 77	45—49 47	69—73 71	46—54 50
Soy beans, medium green, seeding,	1	2	- -	67—67 67	16—29 23	74—76 75	49—50 50	75—77 76	54—61 58
Soy beans, medium green, seeding,	1	4	- -	65—69 67	- -	74—78 76	39—44 44	76—81 79	31—46 36
Soy beans, average all trials,	5	12	-	65	?	75	46	75	48
Spring vetch (*Vicia sativa*),	1	2	62—62 62	- -	- 17	71—72 71	42—46 44	75—77 76	57—60 59
Hairy vetch (*Vicia villosa*),	3	12	66—78 71	- -	33—55 44	79—88 83	52—73 63	68—83 76	63—82 72

(d) Mixed and Miscellaneous.									
Oats and spring vetch, bloom,	1	3	65—69 67	- -	49—55 53	73—76 75	65—72 68	66—70 68	42—52 47
Oats and peas, bloom,	2	5	69—72 70	67—69 68	45—52 49	68—82 74	54—70 64	66—77 72	51—74 64
Oats and peas, partly seeded,	3	5	- -	58—70 62	36—63 47	68—83 74	48—67 55	56—67 63	55—74 64
Winter wheat and hairy vetch,	1	3	68—69 68	- -	40—46 44	75—78 77	66—67 67	71—72 72	56—57 57
Barley and peas, bloom,	3	4	- -	55—71 65	52—55 54	73—81 75	38—61 52	56—76 68	54—65 59
Dwarf Essex rape, first growth,	1	2	88—88 88	- -	76—77 76	90—91 90	90—90 90	94—94 94	54—55 54
Dwarf Essex rape, second growth,	1	2	81	-	47—51 49	86—89 87	84—84 84	90—91 90	42—44 43
Dwarf Essex rape, average,	2	4	85	-	63	89	87	92	48
Skim-milk, with sheep,	1	3	96—102 97	- 100	46—74 62	93—96 94	- -	- 100	- 100
II. — SILAGE.									
Corn silage, dent, immature,	5	13	60—68 64	- -	- -	42—65 54	(?)—78 70	60—70 66	64—85 71
Corn silage, dent, mature,	6	17	60—74 64	- -	- -	45—63 52	45—80 62	63—73 69	78—90 85
Corn silage, dent, stage uncertain,	1	4	53—67 60	- -	- -	19—34 24	43—64 56	61—76 68	55—79 70
Corn silage, dent, Pride of North, mature,	1	2	72—76 74	- -	24—28 26	- 45	72—73 73	81—83 82	72—82 77
Corn silage, flint, mature, small varieties,	4	11	68—78 75	66—80 77	- -	48—73 65	75—79 77	71—83 79	- 82

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
II. — Silage — *Con.*									
Corn silage, flint, large white, partly eared,	1	2	69—70 70	72—73 72	31—37 34	56—56 56	72—72 72	75—76 76	72—74 73
Corn silage, fine crushed, steers,	1	2	60—68 64	- -	- -	32—44 38	72—78 75	60—70 65	75—77 76
Corn silage, fine crushed, sheep,	1	2	51—56 54	- -	- -	21—22 21	59—68 64	53—57 55	67—69 68
Corn silage, mature, fed raw,	1	1	-	-	-	45	59	71	86
Corn silage, mature, cooked,	1	1	-	-	-	39	70	75	87
Corn silage, sweet, mature,	1	2	67—70 68	68—72 70	- -	53—55 54	68—74 71	71—73 72	82—85 83
Cow-pea silage, steers,	1	4	59—60 60	- -	- -	57—58 57	50—54 52	72—73 72	62—64 63
Clover silage, late bloom,	1	2	52—52 52	52—54 53	37—51 44	39—40 40	55—55 55	54—58 56	48—60 54
Oat and pea silage,	1	2	63—68 65	63—70 67	52—53 52	74—75 75	58—65 61	64—70 67	73—77 75
Soy bean silage, goats,	1	2	52—66 59	- -	- -	71—80 76	47—62 55	46—58 52	66—77 72
Soy bean silage, steers,	1	2	50—50 50	- -	- -	54—56 55	42—44 43	61—61 61	47—52 49
Soy bean and barnyard millet silage, sheep,	1	4	54—65 59	- -	- -	55—62 57	61—73 69	54—63 59	69—75 72

Soy bean and corn silage, sheep,	1	3	66—72 69	- -	- -	63—67 65	59—73 65	73—78 75	80—84 82
Silage, mixture of corn, sunflower heads and horse beans.*	1	2	64—68 66	66—70 68	40—41 41	60—65 63	56—64 60	71—74 72	75—78 77
Silage, mixture of corn, sunflowers (whole plant) and horse beans.†	1	2	64—67 65	68—71 69	20—31 26	57—59 58	63—68 65	72—75 74	72—76 74
III.—HAY AND DRY COARSE FODDERS.									
(a) Meadow Grasses and Millets.									
Timothy, in bloom,	3	5	56—66 60	56—67 60	- -	50—60 56	56—62 58	57—72 63	51—62 57
Timothy, past bloom,	5	10	47—61 53	48—62 54	- -	39—50 45	37—57 47	56—70 60	35—61 53
Timothy, average all trials,	20	48	56	57	36	48	51	62	51
Timothy, fed with cotton-seed meal, 16 hay, 1 meal,	1	2	52—56 54	- -	17—28 22	24—32 28	46—52 49	61—63 62	36—37 36
Timothy, fed with cotton-seed meal, 12 hay, 1 meal,	1	2	49—55 52	- -	9—30 20	27—38 32	43—51 47	58—62 60	52—54 53
Timothy, fed with cotton-seed meal, 8 hay, 1 meal,	1	2	44—48 46	- -	3—10 6	18—23 21	40—44 42	53—56 54	42—45 44
Timothy, fed with cotton-seed meal, 4 hay, 1 meal,	1	2	45—46 46	- -	- -	4—4 4	42—43 43	56—75 57	44—66 55
Timothy, fed with cotton-seed meal, 2 hay, 1 meal,	1	2	48—56 52	- -	- 13	- 13	34—44 39	65—71 68	72—74 73
Timothy, fed with cotton-seed meal, 1 hay, 1 meal,	1	2	47—52 49	- -	19—23 21	- -	24—26 25	68—78 73	79—87 83
Timothy, fed with cotton-seed meal, average all trials,	6	12	50	-	16	20	41	62	57
Timothy and clover, poorly cured,	1	2	54—55 55	- -	- -	37—38 38	52—54 53	- 60	- 58

* Proportion of one acre corn, one-fourth acre sunflower heads and one-half acre horse beans.

† Same proportions as above.

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III. — Hay and Dry Coarse Fodders — *Con.*									
(*a*) *Meadow Grasses and Millets* — Con.									
Mixed grasses, rich in protein,	11	46	54—63 60	- -	44—53 48	40—65 59	49—66 60	56—65 61	41—58 50
Mixed grasses, timothy predominating,	2	4	55	-	35	54	58	55	41
Red top,	2	3	58—62 60	59—64 61	- -	60—62 61	61—62 61	59—65 62	44—59 51
Orchard grass, ten days after bloom,	1	1	54	56	-	59	58	54	54
Orchard grass, stage not given,	1	2	57—60 59	- -	- -	60—60 60	60—67 64	55—57 56	55—57 56
Orchard grass, average both samples,	2	3	56	56	-	60	61	55	55
Meadow fescue (*Festuca elatior pratensis*),	1	2	60—61 61	- -	- 46	51—53 52	- 67	58—60 59	53—54 54
Tall oat grass, late blossom (*Arrhenatherum elatius*),	1	2	54—57 55	- -	39—43 41	- 51	53—57 55	56—59 58	54—58 56
Kentucky blue grass (*Poa pratensis*),	1	1	56	-	42	57	63	53	43
Canada blue grass (*Poa compressa*),	1	2	62—63 62	- -	42—42 42	43—44 43	70—71 71	63—63 63	36—39 37
Rowen, mixed grasses,	3	12	- -	63—68 65	- -	- 70	62—72 66	60—69 65	44—51 47
Rowen, chiefly timothy,	1	4	- -	62—67 64	- -	66—69 68	62—73 66	60—65 63	48—51 49

Rowen, average all trials,	4	16	-	65	-	69	66	64	47
Pasture grass,	1	3	73	73	52	73	76	74	67
Meadow, swale or swamp,	1	2	38—40 39	- -	- -	31—37 34	30—36 33	- 46	- 44
Blue-joint, bloom,	1	2	67—70 69	68—71 70	- -	68—72 70	71—73 72	66—71 69	51—53 52
Blue-joint, past bloom,	1	1	40	42	-	57	37	43	37
Buffalo grass (*Bulbilis Dactyloides*),	1	1	55	-	6	54	65	62	62
Prairie grass (*Sporobolus Asper*),	1	1	56	-	25	18	61	61	57
Johnson grass (*Andropogon halepensis*),	2	3	57	-	-	40	68	57	38
Crab grass, ripe (*Eragrostis Neo Mexicana*),	3	8	47—57 53	- -	29—52 43	30—56 38	50—66 60	50—59 53	30—52 43
Chess or cheat (*Bromus secalinus*),	1	1	45	-	23	42	46	49	32
Black grass (*Juncus Gerardi*),	2	5	50—62 56	- -	67—71 69	53—63 58	50—66 59	46—59 52	37—51 44
Fox grass (*Spartina patens*),	3	7	51—56 54	- -	57—59 58	56—63 60	46—60 53	51—55 53	17—51 36
Branch grass (*Distichlis spicata*),	2	5	49—57 52	- -	- 58	- 56	48—57 54	45—55 49	27—42 35
Salt hay mixture, fox and branch grasses, etc.,	1	2	52—56 54	- -	68—70 69	41—43 42	54—61 58	51—54 52	26—30 28
Flat sage (*Spartina stricta maritima var.*),	1	3	55—58 57	- -	61—62 62	50—55 52	60—61 60	54—57 55	33—40 36
Barnyard millet,	1	3	57—58 57	- -	63—64 63	63—64 64	60—64 62	50—52 52	44—50 46
Millet (*Chætochloa italica*),	1	2	52—58 56	- -	16—32 24	30—32 31	60—66 63	52—59 56	48—52 50

Experiments with Ruminants — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III.—HAY AND DRY COARSE FODDERS—*Con.*									
(*a*) *Meadow Grasses and Millets*—Con.									
Hungarian,	1	2	64—66 65	66—67 66	- -	- 60	67—68 68	67—67 67	- 64
Golden millet,	1	1	54	-	31	23	56	58	49
Cat-tail millet (*Pennesetum spicatum*),	1	2	61—64 62	- -	- -	61—65 63	65—68 67	58—60 59	45—48 46
(*b*) *Cereal Fodders.*									
Corn stover, average all trials,	6	18	53—62 57	- -	- -	11—55 36	63—74 66	54—64 59	49—77 65
Corn stover,	1	4	53—55 53	56—58 57	- -	11—22 17	63—67 64	54—59 57	69—77 76
Corn stover, without pith,	1	3	54—57 55	55—59 57	- -	16—28 20	60—65 63	55—58 57	70—75 72
New corn product, stover minus pith, ground,	1	3	63—64 63	- -	46—55 49	57—62 60	60—61 61	65—66 66	82—83 83
New corn product, steamed,	1	3	51—59 56	- -	47—55 50	59—60 60	37—54 48	57—62 59	70—85 80
Average three trials, stover minus pith,	3	9	58	-	-	47	57	61	78
Corn stover, tops and blades,	1	2	59—60 60	- -	- -	54—57 55	71—72 71	62—63 62	71—72 71
Corn stover, blades and husks,	1	4	60—68 65	- -	15—35 23	41—55 48	67—76 73	64—71 66	53—64 58

Corn stover, leaves,	1	2	55—56 56	- -	- -	43—69 56	54—67 61	57—61 59	61—65 63
Corn stover, below ear,	1	2	64—69 67	- -	- -	15—27 21	71—75 74	65—73 69	79—80 80
Corn stover, above ear,	1	2	52—58 55	- -	- -	17—27 22	69—72 71	50—57 54	62—65 64
Corn husks,	1	2	71—73 72	- -	- -	24—35 30	78—81 80	- 75	23—42 33
Corn leaves,	1	2	62—67 65	- -	- -	28—41 35	75—80 78	66—70 68	52—59 56
Kafir corn stover, shredded,	1	4	54—58 56	- -	13—26 19	29—34 30	65—69 67	56—60 58	77—81 79
Kafir corn stover,	1	1	63	-	43	50	67	67	60
Kafir corn stover, average all trials,	2	5	57	-	24	34	67	60	75
Flint corn fodder, ears forming,	1	3	69—72 70	71—73 71	- -	69—73 70	72—73 72	71—73 71	63—71 67
Flint corn fodder, mature,	5	11	63—73 70	- -	- -	56—79 64	69—80 76	63—78 71	59—79 71
Dent corn fodder, ears not formed,	4	8	61—70 65	63—71 67	- -	57—67 62	63—77 71	57—70 64	59—72 66
Dent corn fodder, immature, B. & W.,	1	4	51—64 57	- -	- -	20—36 27	45—74 59	57—66 61	66—84 76
Dent corn fodder, in milk,	5	11	59—66 63	- -	- -	44—51 50	50—71 64	61—69 66	67—79 75
Dent corn fodder, mature, ears ground,	2	8	64—70 67	- -	16—30 23	36—47 43	62—73 68	70—77 74	56—77 66
Dent corn fodder, mature,	8	22	57—70 66	- -	- -	30—61 46	43—73 61	61—81 73	56—82 72

Experiments with Ruminants — Continued.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III. — HAY AND DRY COARSE FODDERS — *Con.*									
(*b*) *Cereal Fodders* — Con.									
Corn fodder, flint and dent, mature,	13	33	57—73 67	- -	- -	30—79 52	43—80 66	61—81 72	56—82 72
Corn fodder, sweet, mature,	3	6	60—71 67	62—74 70	- -	54—73 64	70—77 74	57—73 68	63—71 74
Kafir corn fodder,	1	4	59—62 61	- -	5—11 8	34—42 38	56—63 60	64—68 66	57—67 61
Sorghum fodder, leaves,	1	2	60—66 63	- -	- -	59—62 61	65—76 70	62—67 65	46—47 47
Sorghum bagasse,	1	1	61	-	-	14	64	65	46
Oat hay, bloom to milk,	2	6	51—59 55	50—61 55	35—54 45	47—66 57	54—71 58	47—58 53	41—65 53
Oat hay, milk to dough,	4	14	48—60 54	48—61 54	20—54 37	34—60 52	39—62 48	49—62 56	52—72 64
Oat hay, average all trials,	6	20	54	54	39	53	51	55	60
Barley hay,	1	4	59	62	-	65	62	63	41
Oat straw,	1	2	49—52 50	51—53 52	- -	- -	57—58 58	52—55 53	35—41 38

(c) Legumes.									
Alfalfa, first crop, budded to full bloom,	3	6	56—63 59	- -	34—50 42	61—70 65	31—44 40	68—76 72	26—40 35
Alfalfa, second crop, budded to full bloom,	3	6	58—62 60	- -	38—54 46	64—74 70	41—49 44	70—74 72	36—45 42
Alfalfa, third crop,	1	2	56—60 58	- -	40—49 44	68—70 69	28—40 34	71—71 71	38—45 42
Alfalfa, average three crops,	7	14	60	-	44	68	41	72	39
Alfalfa, average all trials,	13	22	61	-	46	70	43	72	43
Alsike clover, full to late bloom,	4	9	55—64 59	56—65 60	- 42	64—71 66	40—59 50	59—74 66	21—69 38
Red clover,	6	15	51—67 58	52—66 54	0—41 28	47—69 59	44—70 56	57—72 65	40—70 58
Clover rowen,	2	4	- -	58—60 59	42—50 46	60—69 65	45—51 47	62—64 63	58—60 60
White clover,	1	1	66	67	-	73	61	70	51
Crimson clover,	3	9	57—65 62	52—58 56	- -	64—73 69	32—58 45	52—74 62	29—54 44
Sand or hairy vetch,	1	6	68—71 69	- -	34—46 42	81—83 82	60—63 61	71—75 73	69—74 70
Soy bean,	1	2	62—63 62	- -	- -	70—72 71	59—62 61	66—71 69	19—40 29
Cow-pea,	1	2	- 59	- -	- -	64—65 65	41—45 43	- 71	46—54 50
Peanut vine,	1	2	59-60 60	- -	- -	63—64 63	51—53 52	69—70 70	62—70 66

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III. — Hay and Dry Coarse Fodders — *Con.*									
(*d*) *Mixed and Miscellaneous.*									
Oat and pea,	2	7	56—67 61	56—67 60	54—65 58	69—78 73	50—64 58	54—66 61	51—69 59
Oat and sand vetch,	1	2	55—55 55	56—56 56	43—46 44	64—66 65	48—50 49	58—59 59	58—67 63
Oat and spring vetch,	2	5	57—63 59	- 60	- 60	60—71 65	47—67 57	34—65 59	17—76 52
Oat and vetch, average,	3	7	58	58	56	65	55	59	55
Wheat and sand vetch,	1	3	64—65 64	- -	33—37 35	70—71 71	63—66 65	67—67 67	62—67 64
Cotton-seed hulls,	4	13	35—47 41	- -	- -	0—25 6	.5—58 47	13—46 34	58—89 79
Cotton-seed feed (4 to 1, sheep),*	2	6	54—60 56	- -	23—35 28	36—45 41	51—60 56	57—60 59	86—94 91
Cotton-seed feed (5 to 1, steers),	1	3	42—45 43	- -	20—24 22	32—41 36	28—33 31	50—59 54	83—86 84
Cotton-seed feed (7 to 1 and 6 to 1, steers),	1	3	45—46 46	- -	- 28	44—46 45	34—40 37	50—51 50	81—82 82
Cotton-seed feed (4 to 1, steers),	1	2	54	-	46	54	45	58	85
Cotton-seed feed (3 to 1 to 2 to 1, steers),	2	9	54	-	32	64	47	54	85
Average both trials (4 to 1),	3	8	56	-	33	44	53	59	90

Average all trials,	7	23	52	-	30	51	46	55	86
Parson's "Six-dollar" feed,	1	2	55—56 56	- -	10—14 12	56—62 59	45—50 47	63—65 64	80—81 81
Wild oat grass (*Danthonia spicata*),	2	3	60—68 64	61—69 65	- -	49—68 58	65—71 68	62—69 65	38—63 50
Witch grass (*Triticum repens*),	2	4	60—63 61	61—64 62	- -	49—64 58	56—68 62	62—70 66	54—60 57
Buttercups (*Ranunculus acris*),	1	2	56	57	-	56	41	67	70
White weed (*Leucanthemum vulgare*),	1	2	58	58	-	58	46	67	62
IV.—ROOTS AND TUBERS.									
Potatoes,	1	3	73—80 77	75—81 78	- -	43—45 44	- -	87—93 91	- 13
Sugar beets,	1	2	94—95 95	98—100 99	- -	90—93 91	88—113 100	100—100 100	40—53 50
Mangolds,	1	2	77—80 79	83—87 85	- -	70—80 75	27—59 43	91—92 91	- -
English flat turnips,	1	2	91—95 93	93—99 96	- -	84—95 90	89—117 100	96—97 97	82—92 88
Ruta-bagas,	1	2	84—90 87	89—93 91	- -	75—86 80	61—87 74	94—95 95	77—92 84
V.—CONCENTRATED FEED STUFFS.									
(*a*) *Protein Feeds.*									
Cotton-seed meal,	2	6	67—82 76	- -	- -	83—96 88	- 32	44—75 64	87—100 93
Cotton-seed, raw,	1	2	63—69 66	- -	- -	66—70 68	65—86 76	49—50 50	- 87
Cotton-seed, roasted,	1	2	53—58 56	- -	- -	44—50 47	62—69 66	50—53 51	68—75 72

* Four hulls to 1 meal.

Experiments with Ruminants — Continued.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V.—Concentrated Feed Stuffs—*Con.*									
(*a*) *Protein Feeds*—Con.									
Cleveland flax meal,	3	9	76—88 83	- 79	- -	- 83	- -	- 79	- 87
New-process linseed meal,	1	3	73—83 78	- -	- -	82—88 85	49—100 74	82—87 84	90—98 93
Average last two,	4	12	81	-	-	84	-	80	89
Old-process linseed meal,	1	3	75—82 79	- -	- -	86—93 89	38—71 57	76—79 78	85—92 89
Chicago gluten meal,	1	2	87—89 88	- -	- -	87—91 89	- -	93—94 93	92—94 93
King gluten meal,	1	2	79—82 81	- -	- -	- 91	- -	78—81 79	91—97 94
Cream gluten meal,	1	2	92—95 93	- -	- -	83—84 84	- -	85—91 88	96—99 98
Average all gluten meals,	4	8	87	-	-	88	-	88	93
Gluten feed,	5	11	85	-	-	85	76	89	83
Germ oil meal,	2	5	72—83 76	- 75	- -	65—77 73	- -	68—82 76	95—98 96
Chicago maize feed,	1	2	83—85 84	- -	- -	83—84 84	68—76 72	84—87 85	90—90 90

Dried distillery grains, brand R,	1	2	56—59 58	- -	- -	56—63 59	- ?	61—73 67	80—88 84
Dried distillery grains, X brands,	4	8	81	-	-	74	?	82	95
Dried distillery grains, Atlas gluten meal,	1	2	80—80 80	- -	- -	73—73 73	- ?	84—85 84	90—92 91
Dried brewers' grains,	1	2	62—62 62	- -	- -	78—81 79	50—55 53	59—59 59	89—93 91
Malt sprouts,	1	1	67	68	-	80	34	69	100
H-O dairy feed,	1	2	64—67 65	- -	- -	76—80 78	39—43 41	67—73 70	83—88 85
Pea meal,	1	2	85—88 87	86—89 88	- -	80—86 83	25—26 26	93—94 94	52—57 55
Soy bean meal,	2	3	75—79 78	- -	- -	89—91 90	0—73 33	68—73 71	81—98 89
Cow-pea meal,	1	2	85—88 87	- -	22—45 33	80—85 82	62—66 64	92—94 93	74—74 74
Wheat bran, spring,	1	2	62—63 63	- -	- -	78—82 80	22—25 24	70—71 70	76—76 76
Wheat bran, winter,	1	3	57—66 62	- -	- -	75—79 77	- 27	62—76 65	51—80 64
Wheat bran, average all trials,	8	18	62	62	-	77	21	69	66
Wheat middlings, standard,	2	6	-	73	25	77	30	78	88
Wheat middlings, flour,	1	2	79—86 83	- -	- -	82—88 85	33—40 36	84—91 88	82—88 85
Mixed feed, adulterated with corn cobs,	1	3	59—65 62	61—67 64	28—34 31	62—63 63	17—36 28	68—74 71	91—93 92
Rye feed, bran and middlings,	1	3	77—83 82	- -	25—48 35	78—82 80	- -	86—89 88	79—99 90

Experiments with Ruminants — Concluded.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V. — Concentrated Feed Stuffs — *Con.*									
(*b*) *Starchy feeds.*									
Corn meal,	5	14	83—98 89	- 91	- -	40—87 70	- -	85—100 94	71—99 91
Corn and cob meal,	1	3	74—83 79	- -	- -	43—65 52	2—86 45	86—91 88	82—85 84
Kafir corn meal,	2	5	54—76 66	- -	- -	36—62 53	- -	67—84 77	25—62 46
Kafir corn, unground,	2	6	29—58 43	- -	- -	28—54 41	- -	34—62 45	- -
White Kafir heads,	1	4	14—35 24	- -	24—83 54	7—23 12	0—46 27	14—40 31	5—65 31
Cerealine feed,	1	3	89—92 90	- -	- -	79—81 80	72—92 82	93—97 95	78—83 81
Oats, unground,	2	6	66—74 70	68—74 71	2—61 25	72—81 77	15—40 31	74—79 77	87—92 89
Rice meal,	1	2	71—76 74	- -	- -	- 62	- ?	89—95 92	91—92 91
Rye meal,	1	2	85—90 87	- -	- -	83—85 84	- -	89—94 92	63—65 64
Corn bran,	2	4	70—71 70	- -	- -	53—55 54	50—65 59	74—80 77	69—85 77
Rice bran,	1	2	63—66 65	- -	1—4 2	58—68 63	16—42 29	76—81 78	85—92 89

Chop feed, largely corn bran,	2	6	71—92 80	- -	- -	56—77 67	54—70 62	64—92 84	61—86 82
H-O horse feed,	2	3	70—77 74	- 78	-	71—81 75	- -	79—84 82	74—87 81
Corn and oat feed, Victor,	1	3	74—76 75	- -	- -	66—75 71	36—58 48	81—85 83	84—88 87
Oat feed, Quaker,	2	6	62	52	-	72	55	55	72
Oat feed, Royal,	1	3	42—51 47	42—53 48	33—40 37	64—72 69	20—43 33	50—54 51	86—92 88
Oat feed, excessive hulls,	1	3	29—38 34	- -	8—21 13	51—69 62	25—37 32	29—36 33	89—97 92
Oat feed, average last two,	2	6	40	-	25	65	32	42	90
Peanut feed,	1	2	32—32 32	- -	- -	70—71 71	10—13 12	41—58 49	90—90 90
Corn cobs, sheep,	1	2	59—60 59	- -	- -	13—22 17	65—66 65	60—60 60	44—56 50

Experiments with Swine.

Barley meal,	1	1	80	80	-	81	49	87	57
Maize kernels, whole,	1	1	83	83	-	69	38	89	46
Maize meal,	2	2	89—90 90	91—92 92	- -	86—90 88	29—49 39	94—94 94	78—82 80
Maize meal, with cobs,	1	1	76	77	-	76	29	84	82
Old-process linseed meal,	1	4	76—79 77	- -	8—12 10	83—90 86	10—14 12	82—87 85	78—82 80
Pea meal,	1	1	90	92	-	89	78	95	50

Experiments with Swine — Concluded.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
Potatoes,	1	4	97	-	-	84	-	98	-
Wheat, whole,	1	?	72	-	-	70	30	74	60
Wheat, cracked,	1	?	82	-	-	80	60	83	70
Wheat shorts (middlings),	1	2	74—79 77	- -	- -	71—75 73	25—48 37	85—88 87	- -
Wheat bran,	1	2	54—78 66	- -	- -	74—76 75	30—39 34	56—75 66	65—78 72

Experiments with Horses.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
Corn, whole,	1	2	71—78 74	- -	20—32 26	40—76 58	- -	85—92 88	43—52 48
Corn meal, same as above,	1	2	84—93 88	- -	- -	74—77 76	- -	93—99 96	70—76 73
New corn product,	1	2	40—59 50	- -	6—37 22	65—70 68	38—71 55	39—54 47	48—72 60
Oats, whole,	1	2	67—77 72	- -	31—36 33	84—87 86	13—49 31	75—83 79	80—85 82
Oats, ground, same as above,	1	2	73—78 76	- -	9—49 29	81—83 82	.6—28 14	85—87 86	79—81 80

Average of both,	2	4	74	-	31	84	22	82	81
Hay, timothy,	1	2	39—48 44	- -	29—39 34	18—24 21	37—48 43	44—50 47	44—51 47
Experiments with Poultry.									
Corn, whole kernel,	1	3	- -	- 86	- -	44—58 50	- -	90—96 92	88—95 92
Corn meal,	1	3	- -	- 85	- -	41—55 48	- -	91—92 91	92—94 93
Kafir corn, kernels,	1	3	- -	- 88	- -	50—55 53	17—22 20	94—98 96	71—76 74
Kafir meal,	1	3	- -	- 87	- -	42—44 43	30—42 35	95—97 96	82—84 83
Cow-peas,	1	3	- -	- 71	- -	32—48 40	2—43 18	86—88 87	87—90 89
Cow-pea meal,	1	3	- -	- 72	- -	40—49 44	8—11 10	84—91 88	75—98 89

Literature. — The following publications have been consulted in compiling the foregoing tables of digestibility: —

Colorado Experiment Station, Bulletin 8.

Connecticut (Storrs) Experiment Station, reports for 1894–96, 1898.

Hatch (Massachusetts) Experiment Station, reports for 1895–99, 1901; Bulletin 50 and in unpublished records.

Illinois Experiment Station, Bulletins 43, 58.

Kansas Experiment Station, Bulletin 103.

Maine Experiment Station, reports for 1886–91, 1893, 1894, 1897, 1898, 1900.

Maryland Experiment Station, Bulletins 20, 41, 43, 51.

Massachusetts State Experiment Station, reports for 1893, 1894.

Minnesota Experiment Station, reports for 1894–96; Bulletins 26, 36, 42, 47.

Mississippi Experiment Station, report for 1895.

New York Experiment Station, reports for 1884, 1888, 1889; Bulletin 141.

North Carolina Experiment Station, Bulletins 80*c*, 81, 87*d*, 97, 118, 148, 160, 172.

Oklahoma Experiment Station, Bulletins 37, 46.

Oregon Experiment Station, Bulletins 6, 47.

Pennsylvania Experiment Station, reports for 1887–94, 1897, 1898.

Texas Experiment Station, Bulletins 13, 15, 19.

Utah Experiment Station, Bulletins 16, 54, 58.

Wisconsin Experiment Station, report for 1889; Bulletin 3.

INDEX.

PUBLIC DOCUMENT . . . . No. 33.

FIFTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

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HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

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——— ———	*Assistant Horticulturist.*
STEPHEN C. BACON,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins and reports are still in stock and can be furnished on demand : —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 54. Fertilizer analyses.
No. 57. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.
No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 69. Rotting of greenhouse lettuce.
No. 70. Fertilizer analyses.
No. 72. Summer forage crops.
No. 73. Orchard experiments; fertilizers for fruits; thinning fruits; spraying fruits.
No. 75. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 77. Fertilizer analyses.
No. 78. Concentrated feed stuffs.
No. 79. Growing China asters.
No. 80. Fungicides; insecticides; spraying calendar.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.
No. 82. Orchard management; cover crops in orchards; pruning of orchards; report on fruits.
No. 83. Fertilizer analyses.
No. 84. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888–95.
Annual reports for 1897, 1898, 1899, 1900, 1901.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

An outline of the more important work undertaken and the results secured is all the limits of our space will allow. There have been no serious outbreaks of insects during the year. The gypsy moth and brown-tail moth have continued their ravages, while the elm-leaf beetle has been found more

particularly in the north-eastern part of the State. Extensive experiments on the best methods of treatment of the San José scale under New England conditions have been carried on. Six hundred trees have been under observation, and the results of different treatment have been verified by repeated investigations. A bibliographical catalogue of all the scale insects of the world is about completed and will soon be in press.

It has been found that to prevent the mildew on cucumbers grown under glass they should be started as late as possible in the season, and that a dry atmosphere in the house would largely prevent the spread of mildew. Apple-leaf spots were found not to be due to a fungus, as at first supposed, but to exposure to a freezing temperature and to subsequent cold, wet weather. The effect of spraying for leaf spot on linden and elm has been very marked, the foliage being more abundant and remaining green longer. So far as production of fruit is concerned, the experiment of planting cucumbers, watermelons and tomatoes on the edge of fields under tent cloth has proved a failure, because no provision was made for fertilizing the flowers. For sterilizing soil, two-inch pipe with three-sixteenths or one-fourth perforations gives better results than one-inch pipe. Sterilization of soil has marked beneficial results on germination of seeds and subsequent growth of plants; but tomato seeds seem to be an exception to this rule.

In addition to the regular work of the dairy division, with its 3,240 substances analyzed, 2,344 pieces of glass were tested for accuracy. Investigations have been on the following lines: (*a*) examination of butter fat in connection with feeding experiments, to note the effect of various feed constituents upon its character; (*b*) the improvement of methods for determination of the pentosans and starch in feed stuffs; (*c*) determination of the availability of organic nitrogen in fertilizing materials; (*d*) to ascertain the effect of two different milk-condensing processes on the nitrogenous bodies of milk. The pentosans were found to be fully as digestible as the other fodder groups in case of upland hays and most by-products, but rather less digestible in swale hay, salt

grasses and wheat bran. A mixture of winter wheat and sand or hairy vetch was found to be an early and desirable spring green fodder, but for the cost of vetch seed.

In the agricultural division, besides a carefully planned series of experiments to throw light on some of the numerous conditions determining productiveness, — chiefly as affected by different manures and fertilizers, either alone or in a wide variety of combinations, — variety tests with potatoes have been undertaken, with the result that in productiveness the following varieties stood first in the order given: Beauty of Hebron, I. X. L., Steuben, Early Nancy, Million Dollar, Ensign Bagley, Early Rose, Gem of Aroostook, and Daughter of Early Rose.

The details of the experiments thus briefly outlined may be found in the reports of the several divisions herewith submitted.

ANNUAL REPORT

OF GEORGE F. MILLS, *Treasurer* OF THE HATCH EXPERIMENT STATION OF MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1902.

Cash received from United States Treasurer,		$15,000 00
Cash paid for salaries,	$7,366 88	
for labor,	2,224 12	
for publications,	1,205 64	
for postage and stationery,	359 37	
for freight and express,	60 57	
for heat, light, water and power,	765 27	
for seeds, plants and sundry supplies,	530 60	
for fertilizers,	444 25	
for feed stuffs,	210 83	
for library,	140 53	
for tools, implements and machinery,	538 16	
for furniture and fixtures,	28 95	
for scientific apparatus,	59 24	
for live stock,	410 93	
for traveling expenses,	150 57	
for contingent expenses,	131 15	
for building and repairs,	372 94	
		$15,000 00

Cash received from State Treasurer,	$11,200 00	
from fertilizer fees,	3,405 00	
from farm products,	2,274 66	
from miscellaneous sources,	2,319 66	
		$19,199 32
Cash paid for salaries,	$11,966 73	
for labor,	2,012 21	
for publications,	406 36	
for postage and stationery,	321 22	
for freight and express,	132 93	
for heat, light, water and power,	639 40	
Amount carried forward,	$15,478 85	

Amount brought forward,		$15,478 85	
Cash paid	for chemical supplies,	354 53	
	for seeds, plants and sundry supplies,	141 69	
	for fertilizers,	428 05	
	for feed stuffs,	784 50	
	for library,	143 87	
	for tools, implements and machinery,	87 05	
	for furniture and fixtures,	16 40	
	for scientific apparatus,	443 97	
	for live stock,	253 09	
	for traveling expenses,	437 45	
	for contingent expenses,	114 05	
	for building and repairs,	515 82	
			$19,199 32

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1902; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $34,199.32, and the corresponding disbursements $34,199.32. All the proper vouchers are on file. These have been examined by me and have been found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1902.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 26, 1902.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.
Assistants: HENRI D. HASKINS, JAMES E. HALLIGAN, DANIEL L. CLEAVES.

PART I. — Report on Official Inspection of Commercial Fertilizers.
PART II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1902.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 64; of these, 37 have offices for the general distribution of their goods in Massachusetts, 9 in New York, 8 in Connecticut, 3 in Vermont, 1 in Rhode Island, 3 in Canada, 1 in New Jersey, 1 in Maryland, 1 in Ohio and 1 in Illinois.

Two hundred and eighty-three brands of fertilizer, including chemicals, have been licensed in the State during the year. Five hundred and four samples of fertilizers have thus far been collected in the general markets by experienced assistants in the station.

Four hundred and fifty-one samples were analyzed at the

close of November, 1902, representing two hundred and seventy-three distinct brands of fertilizer. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 83, July; and No. 84, November, 1902.

From the above statement it will be noticed that there is a marked increase in the amount of work which is involved in the official inspection of commercial fertilizers from year to year. Four more manufacturers were recorded as having secured licenses for the sale of their goods in Massachusetts in 1902 than in the preceding year. Seventeen more brands of fertilizers were licensed and fifty-five more collected during the past season than in the previous year.

Below will be found an abstract of the results of analyses of official commercial fertilizers for the years 1901 and 1902: —

	1901.	1902.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	7	7
Number with two elements above the highest guarantee,	15	20
Number with one element above the highest guarantee,	51	83
Number with three elements between the lowest and highest guarantee,	142	183
Number with two elements between the lowest and highest guarantee,	91	87
Number with one element between the lowest and highest guarantee,	39	54
Number with three elements below the lowest guarantee,	–	3
Number with two elements below the lowest guarantee,	8	18
Number with one element below the lowest guarantee,	86	67
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	7	10
Number with one element above the highest guarantee,	12	22
Number with two elements between the lowest and highest guarantee,	24	16
Number with one element between the lowest and highest guarantee,	14	13
Number with two elements below the lowest guarantee,	2	4
Number with one element below the lowest guarantee,	14	19
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	7	9
Number between lowest and highest guarantee,	18	14
Number below lowest guarantee,	9	20

The quality of our commercial fertilizers for the past year has been fully as good as in the preceding years, and, with few exceptions, the commercial value of the fertilizer has

not suffered where a discrepancy has occurred between the results of analysis and the manufacturer's guarantee. This would indicate that it was the manufacturer's aim to furnish an article fully equal to his guarantee of composition, and, where a difference has occurred between the analysis and guarantee, that poor mixing is responsible for the discrepancy. It is self-evident that those fertilizers should be selected for general use which furnish the greatest amount of nitrogen, potash and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1901 and 1902 (Cents per Pound).

	1901.	1902.
Nitrogen in ammonia salts,	16.50	16.50
Nitrogen in nitrates,	14.00	15.00
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers.	16.00	16.50
Organic nitrogen in fine bone and tankage,	16.00	16.00
Organic nitrogen in medium bone and tankage,	12.00	12.00
Phosphoric acid soluble in water,	5.00	5.00
Phosphoric acid soluble in ammonium citrate,	4.50	4.50
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

A comparison of the above trade values for 1901 and 1902 shows that the market cost of the different essential elements of plant food remains the same as in 1901, with the exception of nitrogen in form of nitrates and the higher grades of organic nitrogenous fertilizing materials, which show a somewhat higher cost, as compared with the previous year.

The trade values of fertilizing ingredients in raw materials and chemicals are based on the market cost, during the six months preceding March, 1902, of standard raw materials

which enter largely into the manufacture of commercial fertilizers found in our markets. The following is a partial list of such materials: —

Sulfate of ammonia.	Dissolved bones.
Nitrate of soda.	Acid phosphate.
Azotine.	Refuse bone-black.
Dried blood.	Ground phosphate rock.
Cotton-seed meal.	High-grade sulfate of potash.
Linseed meal.	Sulfate of potash and magnesia.
Bone and tankage.	Muriate of potash.
Castor pomace.	Kainit.
Dry ground fish.	Sylvinite.
Dry ground meat.	Crude saltpetre.

As definite instructions have been given from time to time regarding the calculation of the approximate commercial value of fertilizers, no attempt is here made for the discussion of that matter.

Table A, following, gives the average analysis of officially collected fertilizers for 1902; Table B gives a compilation of analyses of commercial fertilizers for the year 1902, showing the maximum, minimum and average percentages of the different essential elements of plant food in special crop fertilizers, so called.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1902.*

NATURE OF MATERIAL.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							Total.		Available.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	11.14	2.29	2.10	4.57	3.57	2.66	10.64	9.29	8.03	7.37	4.96	4.69
Ground bones,	6.92	3.16	2.85	-	9.44	15.12	25.04	22.99	9.44	-	-	-
Tankage,	10.66	3.82	3.56	-	9.01	8.78	17.79	18.00	9.01	-	-	-
Dissolved bone-black,	11.06	-	-	10.16	5.24	1.97	17.68	16.00	15.71	15.00	-	-
Acid phosphate,	10.92	-	-	9.89	4.82	2.40	17.32	15.33	14.72	13.50	-	-
Wood ashes,	13.19	-	-	-	-	-	1.48	1.30	-	-	6.14	4.70
Cotton-seed meal,	7.11	6.48	6.75	-	-	-	-	-	-	-	-	-
Flax meal,	10.43	6.17	6.08	-	-	-	-	-	-	-	-	-
Nitrate of soda,	1.97	15.17	15.40	-	-	-	-	-	-	-	-	-
Sulfate of ammonia,	.82	22.02	19.00	-	-	-	-	-	-	-	-	-
High-grade sulfate of potash,	.81	-	-	-	-	-	-	-	-	-	49.02	48.00
Low-grade sulfate of potash,	.23	-	-	-	-	-	-	-	-	-	25.85	26.00
Muriate of potash,	2.27	-	-	-	-	-	-	-	-	-	50.32	50.00
Kainit,	4.37	-	-	-	-	-	-	-	-	-	12.08	12.00

TABLE B. — *Compilation of Analyses of Commercial Fertilizers for the Year 1902.*

Name of Fertilizer.	Moisture.	Nitrogen in One Hundred Pounds.			Total Phosphoric Acid in One Hundred Pounds.			Available Phosphoric Acid in One Hundred Pounds.			Potassium Oxide in One Hundred Pounds.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer,	12.27	3.48	1.04	2.35	14.20	9.52	11.22	10.65	6.32	8.55	8.88	1.80	4.49
Fruit and vine fertilizer,	9.75	3.44	2.07	2.55	11.82	9.60	10.92	8.70	7.96	8.23	6.78	5.04	5.88
Grain fertilizer,	10.60	6.64	1.82	3.01	17.28	8.88	11.29	10.50	5.22	7.86	12.08	2.20	6.49
Grass fertilizer,	8.56	7.72	2.48	4.08	17.28	5.02	9.24	9.84	2.90	5.87	12.08	2.06	5.86
Market-garden fertilizer,	12.60	3.61	2.02	2.69	12.12	7.70	10.47	9.72	6.30	8.34	10.40	2.18	5.89
Potato fertilizer,	10.87	4.88	1.05	2.54	12.84	7.18	10.58	10.94	4.24	8.39	10.48	2.90	5.30
Tobacco fertilizer,	8.32	6.68	1.76	3.91	13.71	5.38	10.36	11.59	2.84	7.66	14.15	1.54	7.74

The writer wishes to call special attention to Table B, on the preceding page. A comparison of the results in this compilation of analyses of so-called special crop fertilizers reveals a wide difference between the maximum and minimum amount of nitrogen, phosphoric acid and potassium oxide claimed and found in the different brands of commercial fertilizers. In the different brands of tobacco fertilizers, for instance, there is a difference of 4.92 between the highest and lowest percentage of nitrogen, a difference of 8.75 between the maximum and minimum percentage of available phosphoric acid, and a difference of 12.61 between the mean and extreme percentage of potassium oxide which was found. A correspondingly great difference will be observed between the maximum and minimum percentages of plant food found in the several special crop fertilizers which have been compiled in the table. The average farmer is apt to lay too much stress upon the trade name of a fertilizer, and oftentimes buys an inferior article when guided wholly by the name under which it is sold.

There are many things to be taken into consideration in the judicious selection of a fertilizer for growing special crops. The physical and chemical character of the soil and sub-soil, the previous management of the soil and the system of crop rotation employed should all enter into consideration when selecting a fertilizer. A study of the soil should be made by simple local experiments with the different kinds and forms of plant food, to find what elements have become depleted; when these facts have become established, then supply the wants of the soil in the most suitable and economical manner. When the character of a soil is not known and its wants are not manifested, it is advisable to use a fertilizer more nearly corresponding to what a chemical analysis of the crop shows is required for its proper development. For the purpose of illustrating how the chemical composition of a crop may serve as a guide in the compounding of a commercial fertilizer, an example is here inserted. We find the average analysis of potatoes (see compilation of analyses of fruits, garden crops, etc., in annual report of this department for the year 1901) is as follows: —

	Parts per Thousand.
Phosphoric acid,	.70
Potassium oxide,	2.90
Nitrogen,	2.10

The relative proportion of phosphoric acid, potassium oxide and nitrogen present, according to this analysis, is : —

	Parts per Thousand.
Phosphoric acid,	1.00
Potassium oxide,	4.10
Nitrogen,	3.00

In other words, for every pound of phosphoric acid removed from the soil by a crop of potatoes there are 4.1 pounds of potassium oxide and 3 pounds of nitrogen removed. A fertilizer supplying the essential elements of plant food in this proportion would, therefore, under the above-stated conditions, be more suitable to use, as far as potassium oxide and phosphoric acid are concerned, as these elements are supplied only by the soil, while nitrogen is supplied in part by atmospheric sources.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1902, to May 1, 1903), and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- Nitrate of Soda.
- Muriate of Potash.
- High-grade Sulfate of Potash.
- Double Manure Salt.
- Dry Ground Fish.
- Fine-ground Bone.
- Dissolved Bone-black.
- Plain Superphosphate.
- Sulfate of Ammonia.
- Kainit.
- High-grade Fertilizer with Ten Per Cent. Potash.
- Tobacco Starter and Grower.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Bradley's X. L. Superphosphate.
- Bradley's Potato Manure.
- Bradley's Potato Fertilizer.

The American Agricultural Chemical Co. — *Con.*
- Bradley's Complete Manure for Potatoes and Vegetables.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's English Lawn Fertilizer.
- Bradley's Complete Manure with Ten Per Cent. Potash.
- Bradley's Complete Manure for Corn and Grain.
- Bradley's Complete Manure for Top-dressing Grass and Grain.
- Bradley's Grass and Lawn Top-dressing.
- Breck's Lawn and Garden Dressing.
- Brightman's Fish and Potash.
- Church's Fish and Potash.
- Bradley's Seeding-down Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
- Clark's Cove Bay State Fertilizer.
- Clark's Cove Bay State Fertilizer, G. G.
- Clark's Cove Potato Manure.
- Clark's Cove Potato Fertilizer.
- Clark's Cove Great Planet Manure.
- Clark's Cove King Philip Guano.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's Corn Phosphate.
- Crocker's New Rival Phosphate.
- Crocker's General Crop Phosphate.
- Crocker's A. A. Complete Manure.

The American Agricultural Chemical Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.: —
- Blood, Bone and Potash.
- Potato and Root Crop Manure.
- Complete Ten Per Cent. Manure.
- Potato Manure.
- Farm Favorite.

The American Agricultural Chemical Co. (H. J. Baker & Bro., branch), New York, N. Y.: —
- Baker's Complete Potato Manure.
- Baker's A. A. Ammoniated Phosphate.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.: —
- Northern Corn Special.
- Grass and Oats Fertilizer.
- General Fertilizer.
- Garden Special.
- Vegetable Vine and Tobacco.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.: —
- Pacific High-grade General.
- Soluble Pacific Guano.
- Pacific Potato Special.
- Pacific Nobsque Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.: —
- Animal Corn Fertilizer.
- Potato Manure.
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.
- Gardener's Complete Manure.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
- Quinnipiac Onion Manure.
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Corn Manure.
- Quinnipiac Market-garden Manure.
- Quinnipiac Havana Tobacco Fertilizer.
- Quinnipiac Climax Phosphate.
- Quinnipiac Potato Phosphate.
- Quinnipiac Dissolved Bone.

The American Agricultural Chemical Co. (Read Fertilizer Co., branch), New York, N. Y.: —
- Read's Farmers' Friend.
- Read's Practical Potato Special.
- Read's Vegetable and Vine.
- Read's High-grade Farmers' Friend.
- Read's Standard.

The American Agricultural Chemical Co. (Standard Fertilizer Co., branch), Boston, Mass.: —
- Standard Fertilizer.
- Standard Guano.
- Standard Complete Manure.
- Standard Special for Potatoes.

The American Agricultural Chemical Co. (Henry F. Tucker Co., branch), Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Special Potato Fertilizer.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
- Williams & Clark's High-grade Special.
- Williams & Clark's Americus Phosphate.
- Williams & Clark's Potato Phosphate.

The American Agricultural Chemical Co. — *Con.*
- Williams & Clark's Corn Phosphate.
- Williams & Clark's Potato Manure.
- Williams & Clark's Royal Bone Phosphate.
- Williams & Clark's Prolific Crop Producer.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.: —
- Corn Fertilizer.
- Potato Manure.
- Superior Truck Fertilizer.
- Bermuda Onion Grower.
- Grass and Oats Fertilizer.
- Havana Tobacco Fertilizer.

W. H. Abbott, Holyoke, Mass.: —
- Animal Fertilizer.
- Eagle Brand.
- Tobacco Fertilizer.

The Abbott & Martin Rendering Co., Columbus, Ohio: —
- Abbott's Tobacco and Potato Special.

The American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-seed Hull Ashes.

American Linseed Co., New York, N. Y.: —
- Cleveland Flax Meal.

Armour Fertilizer Works, Baltimore, Md.: —
- Blood, Bone and Potash.
- Ammoniated Bone with Potash.
- Grain Grower.
- All Soluble.
- High-grade Potato.
- Bone Meal.

H. J. Baker & Bro., New York, N. Y.: —
- Castor Pomace.

Bartlett & Holmes, Springfield, Mass.: —
- Animal Fertilizer.
- Pure Ground Bone.
- Tankage.

Berkshire Fertilizer Company, Bridgeport, Conn.: —
- Berkshire Complete Fertilizer.
- Berkshire Ammoniated Bone Phosphate.
- Berkshire Potato and Vegetable Phosphate.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Market Garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Fertilizer.
- Bowker's Fish and Potash "Square Brand."
- Bowker's Potato Phosphate.
- Bowker's Sure Crop Phosphate.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Superphosphate.
- Bowker's Ground Bone.
- Gloucester Fish and Potash.
- Dissolved Bone-black.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.
- Wood Ashes.
- Fine Dry Ground Fish.
- Bone, Blood and Potash.
- Fish and Potash D Brand.
- Bristol Fish and Potash.
- Corn Phosphate.
- Tobacco Ash Elements.
- Early Potato Manure.
- Sulfate of Ammonia.

Butchers' Rendering Co., Fall River, Mass.: —
- Tankage.

Chas. M. Cox & Co., Boston, Mass.: —
- Cotton-seed Meal.

E. Frank Coe Co., New York, N. Y.: —
- E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
- E. Frank Coe's Gold Brand Excelsior Guano.

E. Frank Coe Co. — *Con.*
- E. Frank Coe's Tobacco and Onion Fertilizer.
- E. Frank Coe's Bay State Phosphate.
- E. Frank Coe's F. P. Fish and Potash.
- American Farmers' Market Garden Special.
- American Farmers' Complete Potato.
- American Farmers' Corn King.
- Excelsior Potato Fertilizer.
- Columbian Corn Fertilizer.
- Columbian Potato Fertilizer.
- New Englander Corn Fertilizer.
- New Englander Potato Fertilizer.
- Columbian Bone Superphosphate.
- X. X. X. Ground Bone.
- Red Brand Excelsior Guano.

John C. Dow & Co., Boston, Mass.: —
- Dow's Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Imperial Liquid Plant Food.
- Imperial Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
- Canada Unleached Hard-wood Ashes.

R. & J. Farquhar & Co., Boston, Mass.: —
- Clay's London Fertilizer.

Thomas Hersom & Co., New Bedford, Mass.: —
- Meat and Bone.
- Bone Meal.

F. E. Hancock, Walkerton, Ontario, Can.: —
- Pure Unleached Hard-wood Ashes.

The Hardy Packing Co., Chicago, Ill.: —
- Hardy's Tankage, Bone and Potash.
- Hardy's Tobacco and Potato Special.
- Hardy's Complete Manure.

C. W. Hastings, Cambridgeport, Mass.: —
- Ferti Flora.

John Joynt, Lucknow, Can.: —
- Pure Canada Unleached Hardwood Ashes.

Thomas Kirley & Co.'s Fertilizer Works, South Hadley Falls, Mass.: —
- Pride of the Valley.

Lister's Agricultural Chemical Works, Newark, N. J.: —
- Lister's Success Fertilizer.
- Lister's Special Corn and Potato Fertilizer.
- Lister's High-grade Special for Spring Crops.
- Lister's Animal Bone and Potash.

Lowell Fertilizer Co., Boston, Mass.: —
- Swift's Lowell Bone Fertilizer.
- Swift's Lowell Potato Phosphate.
- Swift's Lowell Market Garden.
- Swift's Lowell Tobacco Manure.
- Swift's Lowell Potato Manure.
- Swift's Lowell Animal Brand.
- Swift's Lowell Fruit and Vine.
- Swift's Lowell Dissolved Bone and Potash.
- Swift's Lowell Ground Bone.
- Nitrate of Soda.
- Muriate of Potash.
- Swift's Lowell Lawn Dressing.
- Acid Phosphate.

McQuade Bros., West Auburn, Mass.: —
- Ground Bone.

Geo. L. Munroe, Oswego, N. Y.: —
- Pure Canada Unleached Hardwood Ashes.

Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- Potato Manure.
- Tobacco Starter improved.
- Tobacco Manure Wrapper Brand.
- Fruit and Vine Manure.
- Economical Potato Manure.
- Average Soil Complete Manure.
- Vegetable Manure or Complete Manure for Light Soils.
- Corn Manure.
- Complete Manure "A" Brand.
- Cereal Brand.
- Complete Manure Ten Per Cent. Potash.
- Complete Manure for General Use.

Mapes Formula and Peruvian Guano Co. — *Con.*
- Cauliflower and Cabbage Manure.
- Lawn Top-dressing.
- Grass and Grain Spring Top-dressing.
- Top-dressing improved, One-half Strength.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Complete Fertilizer.
- Chittenden's Market Garden.
- Chittenden's Potato Phosphate.
- Chittenden's Fish and Potash.
- Chittenden's Ammoniated Bone.
- Chittenden's Universal Phosphate.

New Bedford Product Co., New Bedford, Mass.: —
- Tankage.

New England Fertilizer Co., Boston, Mass.: —
- Corn Phosphate.
- Potato Fertilizer.
- Seeding-down Fertilizer.

Olds & Whipple, Hartford, Conn.: —
- Complete Tobacco Fertilizer.
- Vegetable Potash.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Special Potato.
- Star Brand.
- P. & P. Potato.
- A. A. Brand.
- Pure Ground Bone.
- Nitrate of Soda.
- Muriate of Potash.

Benjamin Randall, Boston, Mass.: —
- Market Garden.
- Farm and Field.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Pure Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.

Rogers & Hubbard Co. — *Con.*
- Hubbard's Oats and Top-dressing.
- Hubbard's Soluble Potato Manure.
- Hubbard's Corn and General Crops.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's Grass and Grain Fertilizer.
- Hubbard's All Soils and All Crops Fertilizer.
- Hubbard's Potato Phosphate.
- Hubbard's Corn Phosphate.
- Hubbard's '02 Top-dressing Phosphate.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Round Fertilizer.
- Complete Potato and Vegetable.
- Complete Corn and Onion.
- Complete Fish and Potash.
- High-grade Grass and Grain.
- High-grade Tobacco and Potato.
- High-grade Oats and Top-dressing.
- High-grade Soluble Tobacco.
- Pure Fine Ground Bone.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex Complete Manure for Potatoes, Roots and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Market Garden and Potato Manure.
- Essex A. L. Superphosphate.
- Essex X. X. X. Fish and Potash.
- Essex Odorless Lawn Dressing.
- Essex Special Tobacco Manure.
- Essex Tobacco Starter.
- Essex Corn Fertilizer.

Chas. Stevens, Napanee, Ontario, Can.: —
- Beaver Brand Ashes.

Salisbury Cutlery Handle Co., Salisbury, Conn.: —
- Fine Bone.

Sanderson's Fertilizer and Chemical Co., New Haven, Conn.: —
Sanderson's Old Reliable.
Sanderson's Formula A.
Sanderson's Formula B.
Sulfate of Potash.

Thomas L. Stetson, Randolph, Mass.: —
Bone Meal.

J. Stroup Son & Co., Boston, Mass.: —
Canada Hard-wood Unleached Wood Ashes.

Jas. P. Trainor, Jamesville, Mass.: —
Pure Ground Bone.

Darius Whithed, Lowell, Mass.: —
Champion Animal Fertilizer.
Flour of Bone.

The Whitman & Pratt Rendering Co., Lowell, Mass.: —
Whitman & Pratt's Potato Plowman.
Whitman & Pratt's Corn Success.
Whitman & Pratt's Pure Ground Bone.

Wilcox Fertilizer Works, Mystic, Conn.: —
Complete Bone Superphosphate.
Potato Manure.
Fish and Potash.
High-grade Tobacco Fertilizer.
Dry Ground Fish.

Sanford Winter, Brockton, Mass.: —
Pure Fine-ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
Tankage.

Part II. — Report on General Work in the Chemical Laboratory.

CHARLES A. GOESSMANN.

1. Analysis of materials sent on for examination.
2. Notes on wood ashes.

1. Analysis of Materials sent on for Examination.

During the season of 1902, 217 samples of fertilizing materials, soils, etc., have been received from farmers within our State. The results of analysis of these substances have been published, when deemed of importance to the general public, in three bulletins: No. 81, March; No. 83, July; and No. 84, November, 1902, of the Hatch Experiment Station of the Massachusetts Agricultural College.

Nearly every manufacturing industry has its by-products, which have often a distinct value for manurial purposes. The use of this class of materials has been encouraged whenever the chemical analysis of the same proves them to be of sufficient value to merit their use. The investigation of general fertilizing material of this nature is carried on free of charge to farmers in the State; the material is taken up for analysis in the order of arrival of samples at this office. We have advised farmers to send material for free analysis as early in the season as possible, as work of this nature has to be suspended during the rush of official inspection work during the spring and summer months. Following is a list of materials received during the past season: —

Wood ashes,	52	Dry ground fish,	10
Miscellaneous material,	25	Ground bones,	6
Soils,	35	Onions,	8
Complete fertilizers,	22	Natural phosphates,	6

Cotton-seed meal,	4	Castor pomace,	1
Horn dust,	3	Sulfate of potash,	1
Mill waste,	2	Hemp ashes,	1
Wool waste,	3	Air-slaked lime,	1
Sheep manure,	2	Nitre lime,	1
Tankage,	2	Nitrate of soda,	1
Barnyard manure,	2	Low-grade sulfate of potash,	1
Acid phosphate,	2	Dissolved bone-black,	1
Carbonate of potash,	2	Muriate of potash,	1
Lime ashes,	2	Sulfate of ammonia,	1
Paris green,	1	Mold from compost pile,	1
Basic slag,	1	Waste ashes,	1
Pulverized rock weed,	1	Burned bone,	1
Coral formation,	1	Turf,	1
Leaf mold,	1	Tan-bark ashes,	1
Peat,	1	Brick-yard ashes,	1
Vegetable potash,	1	Sizing paste,	1
Tobacco stalks,	1	Sewage,	1
Cotton-hull ashes,	1	Acetylene tank refuse,	1
Celery plant,	1		

As in the past, we have collected and analyzed samples of Paris green and other insecticides found in our general markets. The analysis of these materials will be found in our March bulletin, No. 81, for 1902.

We have been engaged in work for the Association of Official Agricultural Chemists, to assist in the selection of the best methods of analysis of insecticides, etc., and have taken up co-operation work for the association on new methods of potash determination. The results of this work do not appear in our publications, the work being of technical nature, and of value only to the Association of Official Agricultural Chemists in the establishment of new methods of analysis.

We are constantly occupied with investigations of new methods for the determination of the available plant food in soils, and new and improved methods for the ash analysis of plants, and have been to considerable expense in procuring the equipment for the latter work, being obliged to import most of the apparatus from Germany. The equipment con-

sists of a power mill (*Kugelmuhle*) to be used in the preparation of the plant for analysis, and which eliminates all danger of the contamination of the sample with iron or other metallic substances, the grinding being accomplished by means of porcelain balls revolving within a tightly sealed porcelain vessel. In this connection we have imported suitable platinum apparatus, recommended by Wislicenus, Tollens and others, for the purpose of securing the ashes of plants at a low temperature; its structure being such as to eliminate all danger of the volatilization of potash, soda, phosphoric acid and other mineral constituents of plants. Attention has also been directed to the investigation of the available phosphoric acid in natural phosphates. The results of investigations above mentioned will be published from time to time, whenever the results prove of general interest and value to the public.

2. Notes on Wood Ashes.

During the season of 1902, 24 per cent. of the materials forwarded for analysis consisted of wood ashes. The following table shows their general chemical character: —

Analysis of Wood Ashes.	Number of Samples.
Moisture below 1 per cent.,	2
Moisture from 1 to 10 per cent.,	18
Moisture from 10 to 20 per cent.,	22
Moisture from 20 to 30 per cent.,	6
Potassium oxide from 7 to 8 per cent.,	4
Potassium oxide from 6 to 7 per cent.,	8
Potassium oxide from 5 to 6 per cent.,	21
Potassium oxide from 4 to 5 per cent.,	12
Potassium oxide from 3 to 4 per cent.,	2
Potassium oxide below 3 per cent.,	1
Phosphoric acid from 1 to 2 per cent.,	46
Phosphoric acid below 1 per cent.,	2
Average per cent. of calcium oxide (lime),	32.18
Insoluble matter below 10 per cent.,	15
Insoluble matter between 10 and 15 per cent.,	17
Insoluble matter between 15 and 20 per cent,	13
Insoluble matter above 20 per cent.,	3

The average standard of this class of materials remains about the same as in previous years.

Farmers have been advised to patronize dealers and importers of wood ashes who are on record at our institution as having complied with our State laws and secured licenses for the sale of their article in Massachusetts, for only in such cases is a protection by our State laws possible. We have also urged them to state in every case the particular source from which the materials forwarded for free analysis have been derived.

REPORT OF THE HORTICULTURIST.

F. A. WAUGH.

During the year the work of the division of horticulture has been extensively reorganized. These changes have been necessitated partly by new conditions and partly by a change in the administration of the division. The principal innovations are three, as follows : —

1. The abandonment of miscellaneous variety tests, and the substitution, in their place, of systematic studies of varieties from all sources and under all conditions.

2. The establishment of definite lines of experiment designed to develop the principles underlying the practice of fruit and vegetable culture.

3. The opening of an extensive system of permanent records, which are expected to hold together the work of successive years, to assist in the interpretation of current observations by offering a comparison with previous results, to make possible the accumulation of comparable data through a period of years, to make the results of experiments at all times available, and, in general, to secure definiteness of aim, clearness of interpretation and consectivity of work in all the experimental operations of the division.

There is no need of publishing at this time a full programme of the experimental work already determined on. It may be proper to say, however, that the work is planned to cover certain important practical problems in the propagation and cultivation of orchard fruits, particularly apples, peaches and plums, and similar investigations in the culture of small fruits and vegetables.

As has been the practice hitherto, every effort will be made to furnish prompt and reliable information in response to the many inquiries which are sent in from day to day.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

Plant Diseases in 1902.

Diseases affecting cultivated plants have, as usual, caused more or less damage during the past season. The following pages describe briefly the occurrence of the most important.

Peach-leaf Curl (*Exoascus deformans*).

This fungus was rather more prevalent than usual early in the season. Its effects were most noticeable upon young trees, particularly upon Elberta and Crosby, these varieties being attacked to the exclusion of others in the same orchards. Though very destructive in many portions of the country, it is not commonly a serious one in Massachusetts.

Apple-leaf Spot.

One of the most noticeable troubles of the season has been the injury to apple foliage caused by frost, which is described elsewhere in this report. Many trees, after the spotting and yellowing of the leaves early in the season, were quite denuded by midsummer. Well-cared-for trees were not often affected, so that the actual damage from this source was probably very slight.

Sycamore Blight (*Glœosporium nervisequum*).

This disease was, as usual, very severe, causing the fall of almost all the leaves on sycamore trees during June and July.

Strawberry Root Rot.

This apparently new trouble of the strawberry plant (see p. 34) was much complained of in new beds set out this season.

Apple Scab (*Fusicladium dendriticum*).

Both early and late apples were badly affected by scab during the year, except on high ground.

Cucumber Wilt.

This bacterial disease was more prevalent than ever before in large cucumber fields, and is evidently on the increase, though no great damage resulted this year.

Sweet Pea Troubles.

The cool, moist summer proved very favorable to the growth of this plant, and much less trouble than for several years was experienced by large growers. The "shelling" of the buds and blossoms, brought on by close, muggy weather, occurred somewhat; but the blight of the vines, so common and destructive of late, appeared very little this season.

Aster Diseases.

The "yellow" disease of this plant was noticeably less abundant than usual this year, its prevalence being evidently influenced by the character of the season. The wilt or stem rot proved very destructive in many plants started in the greenhouse, while those grown entirely out of doors were comparatively free from its attack.

Potato Blight (*Phytophthora infestans*).

This disease came on somewhat later than usual, being retarded by cool weather early in August. It soon became prevalent, however, and rotting of the tubers was unusually severe, the crop being greatly diminished.

Cucumber and Melon Diseases.

These plants suffered greatly during the season from a variety of causes, chief among which was the downy mildew (*Plasmopara cubensis*), the unusual prevalence of which is described more fully elsewhere in this report. The *Alternaria* disease and anthracnose were also common. Muskmelons were a total failure everywhere, and cucumbers were

considerably injured. The cold, wet season proved very unfavorable to the melon crop, so that the vines readily succumbed to disease.

Asparagus Rust (Puccinia Asparagi).

Asparagus plants were affected by rust much less than in previous years, demonstrating the influence of conditions of weather upon this disease.

Chrysanthemum Rust (Puccinia Hieracii).

The destructiveness of this disease, which has seriously threatened the chrysanthemum, is evidently declining. Cases of its occurrence have been very few this season, and no serious damage has been evident.

The Cucumber Mildew in Massachusetts (Plasmopara Cubensis (B. & C.) Humph.).

The general occurrence of this disease during the past season upon cucumbers and melons calls attention to its peculiar history in this State. The fungus was described from Cuba many years ago, but was discovered in this country in 1889, when it appeared in Massachusetts, New Jersey and other States at about the same time. In the report of the Massachusetts Experiment Station for 1889, Dr. Humphrey, then of this division, noted the occurrence of the disease, calling attention to the serious damage which its general distribution might cause. In subsequent years this mildew became very prevalent throughout the southern and middle States, causing great damage each year to cucumbers and melons as far north as Long Island, but not in New England. From this limited distribution it appeared that the fungus required a somewhat warmer climate than ours for its normal development.

In the autumn of 1900 the downy mildew appeared again in this State, being found upon greenhouse cucumbers in two different localities, as noted in the report of this division for that year. These were the only cases known at that time. The next season the muskmelon crop all over the State was quite generally affected and destroyed by this fungus, which

also occurred abundantly upon greenhouse cucumbers, but was not observed upon the latter plant when grown out of doors. During the past season (1902) muskmelons have been almost a total failure from this cause; and cucumbers, both in and out of doors, have been generally affected, the fungus being abundant everywhere upon these two plants.

Thus it appears that for the past three years this fungus has been steadily increasing in its distribution. Its most serious effects in this State have been upon the muskmelon. Scarcely a single melon was obtained this year by most of the growers, the vines being killed completely within a few days' time. Experiments in spraying, made in co-operation with this division in several different places, have shown but little gain. It seems quite evident, in fact, that so long as this disease continues to prevail the muskmelon cannot be grown in Massachusetts. The plant is not naturally adapted to our climate, and succeeds at best only in favored localities. When attacked by disease it succumbs very easily, especially in such an unfavorable season as the past one has been.

Upon the cucumber, the disease, while general, is as yet by no means as serious. Out-of-door fields showed the fungus everywhere this year, but the vines remained alive for some time, and the yield did not appear to be seriously diminished. This, however, is but one year's experience.

The effect of this disease upon greenhouse cucumbers is perhaps the most important consideration of the whole subject. Here is an industry of considerable and very rapidly increasing importance in this State, involving, relative to most other agricultural industries, a large amount of capital. It is one in which success means good profits and failure large losses. No serious obstacle which cannot be overcome has as yet been met with, but considerable alarm has been caused by the general appearance of the downy mildew. It may be said, however, that thus far no great damage has been evident. It is noticeable that the disease is most serious in the greenhouse upon plants started in August, which is the time of its occurrence out of doors. Those started later in the season or in spring do not seem to suffer. Even when present in the house, the disease does

not kill the vines outright, and by picking off the affected leaves growers have succeeded in keeping it considerably in check. It is therefore recommended that greenhouse cucumbers be started as late as possible, to avoid the mildew. Plants started in October have not shown the disease, where those planted in August were badly affected. This is the safest and easiest preventive. In case this is impracticable, on account of an early crop being desired, a dry atmosphere in the house will largely prevent the spread of the mildew, the development of which is favored by atmospheric moisture. By removing affected leaves, and keeping the house dry, the disease can be effectually kept down. A third remedy lies in spraying, which must be resorted to with an early crop in moist atmosphere. This has been practised very successfully with out-of-door cucumbers upon Long Island, using the Bordeaux mixture. Spraying can be done thoroughly in the greenhouse, and both sides of the leaves should be well covered.

The Muskmelon Blight.

On account of the general prevalence and general destructiveness of this disease, melon growing has become practically impossible in Massachusetts. This plant, as described in our last report, has become affected worse and worse each year with several different fungous diseases, the attacks of which its delicate nature has little power to resist. The chief trouble this year and last has been the downy mildew, in connection with which the anthracnose and *Alternaria* disease have also developed. The cold weather of the last season was very unfavorable for muskmelons, making it almost impossible to get vigorous plants started. Those started in-doors and transplanted made practically no growth for weeks after being set out, and fell an easy prey to disease. The *Alternaria* disease appeared about July 15, but appeared to cause no immediate damage; but the mildew, coming on in the latter part of August, killed the vines completely all over the State, and no returns whatever were received from many large fields. After these two years of complete failure since the mildew appeared, it is probable

that but few attempts will be made in the near future to grow this crop.

The subject of spraying as a preventive for this trouble has received considerable attention from this division for several years. During the past season experiments were made in co-operation with a local grower along the lines which previous experience had suggested. The details of this work will be reserved for a bulletin ; but it may be said here that, even where plants were thoroughly sprayed with Bordeaux mixture, commencing early in July when the first leaves developed, no effect could be seen upon the development of the mildew. Sprayed and unsprayed plots and fields were alike a complete failure. It therefore seems quite evident that, so long as this disease continues to prevail, the muskmelon cannot be grown here under ordinary treatment. In seasons favorable to the plant, persistent spraying with good culture may give some returns ; but in a poor year the crop is almost sure to be a failure, in spite of anything which can be done to save it. The plant is too poorly adapted to our climate to withstand a serious disease.

An Apple-leaf Spot.

One of the most frequent subjects of inquiry of this division during the past summer was a spotting and dying of apple leaves, which occurred very generally in this and other States. The trouble was first noted in May or early June, when trees affected showed a spotting of the leaves resembling a fungous leaf spot. This occurred quite generally, but usually on trees in pastures and by roadsides, rather than in well-kept orchards. The spotting was also more evident on low, frosty ground. With the advance of the season the spotting became much more marked, the foliage gradually turning yellow and dropping from the trees. This became very noticeable and caused considerable alarm, being in striking contrast to the usual healthy condition of apple foliage. Good orchard trees were in few cases seriously affected, though in some the spotting came on rather late in the season. The trouble prevailed mostly in neglected trees growing under unfavorable conditions; most of these lost their leaves during the summer.

Investigation of affected leaves failed at all times to show any fungus or other organism which could be regarded as the cause of the spotting, but revealed peculiarities which point to a cause of quite a different nature; namely, the occurrence of freezing temperature and frost at the time the leaves were unfolding, and subsequent cold, wet weather to an unusual extent throughout the season. At the time when apple trees were leaving out, a period of very low temperature came on, with frost and ice. Immediately following this the first spotting of the leaves appeared, being most noticeable in the most frosty places. Affected leaves showed numerous dead spots, especially near the veins, where would be the largest amount of water. In these spots the tissue was dead and ruptured. No organism was to be found as the cause of the injury, and from the sequence of events there could be no reasonable doubt that the frost was the destructive agency. As the season progressed, these leaves gradually dropped off, as might be expected. Further than this, however, the spotting of the leaves gradually increased through the summer, so that in the latter part of the season trees were affected which had not shown the trouble at first, while those originally affected lost almost all their leaves. This at first sight seemed to render it impossible that the trouble was due to the spring frost, since much of the spotting did not appear until August, particularly in well-cared-for orchards. In all these cases, however, the injurious effects were undoubtedly due to the same original cause. Careful microscopic examination of leaves when first affected showed not only the actual dead spots, but also many other portions affected in a peculiar manner. Here and there on the leaf could be found minute, blister-like spots, retaining at first the natural green color. In these places freezing had evidently occurred, causing more or less mechanical injury to the tissues, but not sufficient to cause immediate death. The epidermis became separated from the underlying cells, and more or less ruptured. In such spots, apparently, originated the trouble manifested later in the summer. The weather, being abnormally wet and cold, produced a low state of vitality, so that the tissue gradually died away in these injured places, and visible dead spots

appeared. Orchard trees in good condition were perhaps less affected in the first place, and subsequently were better able to withstand the injury, owing to their better condition. This trouble is an unusual one, of more interest on account of its peculiar nature than from any economic importance.

A Strawberry Disease.

Many complaints were made during the past summer of the dying of strawberry plants set out in new beds. The same also occurred to a much less extent in old beds at the time of fruiting. In the latter case the trouble appeared as a withering and dying of the fruit stalks, followed by the same effect in the leaves. Much more pronounced was the case of the new beds, where in numerous instances many of the young plants withered away in July, showing symptoms of a very definite nature. The first indications of the disease appeared in the leaf stalks, which showed a dark discoloration and withering. Following this the leaves slowly faded away, the whole plant finally becoming dead. The trouble at first sight appeared to be located in the petioles, where the black spots first appeared. Examination of these parts, however, showed no fungus present, nor anything which would account for the effect. The roots of affected plants were found in all cases to be in very poor condition, the older ones being decayed and little new growth present, as should be the case where the plants had been set out some time. Further examination showed that a fungous growth was present in almost all the roots of affected plants, apparently causing them to rot away at the ends. Even in the sound parts this fungus could be detected, growing in from the outside toward the centre. In affected plants from many different localities the same condition was found, so that there can be little doubt that the withering of the petioles and leaves was due to the rotting of the roots. Attempts were made to obtain cultures of the fungus, in order to determine its identity more definitely and test its effect upon healthy plants. As this was not accomplished, no definite conclusions can be drawn as to the actual cause of the disease. The cold, wet weather of the past season would nat-

urally tend to aggravate a trouble of this nature, but its general and characteristic occurrence indicates the presence of a more definite cause than this. Should the disease continue to prevail, care should be taken in starting new beds to propagate only from healthy, vigorous plants.

Plum "Yellows."

A disease apparently similar to the "yellows" of the peach has been noticed for several years upon the college grounds. It occurs only upon the Japanese varieties, particularly the Abundance, and is as yet of no serious consequence. The trouble is characterized by the production of wiry yellow shoots, just as in the peach yellows.

Spraying of Linden and Elm Trees for Leaf Spot.

Both of these shade trees are frequently affected with leaf-spot fungi, which sometimes becomes quite abundant, causing the leaves to fall prematurely. Some lindens on the college grounds become badly affected each year with leaf spot (*Cercospora microsora*), while other much younger trees show little or no trace of it. The older, infected trees are also more or less injured by borers, and many of the younger trees show the effects of sun scald on their trunks. The presence of the leaf spots on the older trees in such abundance is probably secondary, *i.e.*, the trees are in such poor condition they induce leaf spot to thrive. Elms are not so badly affected with the leaf spot (*Dothidella ulmea*) as lindens with the *Cercospora*. Some lindens and elms were sprayed twice this summer, viz., July 12 and August 13. The result of this spraying was very marked. The sprayed linden trees could be easily identified by any one during September and October, on account of the more abundant foliage and greener color of the leaves. The foliage remained on the sprayed trees some days longer than on the unsprayed ones. While the sprayed trees were affected to some extent with the spot fungus, there was a decided difference in the amount of infection between the treated and untreated. Better results would undoubtedly have been obtained if

the lindens had been sprayed earlier, or about July 1, as at the time of the first spraying the spot was beginning to appear.

None of the elm trees, either the sprayed or unsprayed, developed much of the leaf spot. All that can be said in favor of the sprayed trees is that their foliage remained green longer than the other trees, and the trees retained their leaves the latest of any. We estimate that linden trees affected as these were, if sprayed twice during the season, would result in a gain of from two to five per cent. in their growth and development. The cost of spraying was insignificant, as the trees were not large. The question involved in all such instances is, whether the tree is worth the expense. This depends on the owner's interest in such matters, and in the means and facilities to have such work done.

Crops under Tent Cloth.

Much interest has been manifested in Massachusetts and Connecticut in the last two or three years in growing Sumatra tobacco under tent cloth. That the environmental conditions of plants are greatly modified under tent cloth is well known. Besides exerting a characteristic influence on the texture of the plants, we might expect, from our knowledge of the conditions which favor fungous infection, that the conditions prevailing under tent-cloth culture would result in producing in certain cases beneficial results. In some instances tobacco growers have planted cucumbers, watermelons, tomatoes, etc., on the border of tobacco beds planted under tent cloth, largely as a matter of curiosity, to see how they would develop under these conditions. So far as the production of fruit is concerned, it may be stated that these experiments have been a failure, because no adequate provision was made to fertilize the flowers. As a result of this, plenty of fruit set but did not mature. The foliage of watermelons which was observed under tent cloth was in excellent condition. We noticed, however, on a few vines about a dozen leaves affected with *Alternaria*, which, however, showed no tendency to spread. Muskmelons developed good vines and foliage, but towards the latter part

of the season they showed some of the usual blights. The foliage of tomato plants which we observed was absolutely perfect, there being no trace of the flea beetle or *Macrosporium*. None of the crops developed any fruit of any consequence. The melons, etc., should have been provided with bees to fertilize the flowers, and the tomatoes should have been shaken frequently, to accomplish the same purpose. Cucumbers did well, but failed on account of bees to set fruit. It is generally agreed by growers that the foliage produced under tent cloth was of superior quality, though, on account of the inability of the crops to set fruit, they were considered a failure. The foliage of geraniums and other decorative plants was excellent, and the geraniums showed no tendency to a leaf spot which had been rather abundant during the past summer. Our experiments in growing muskmelons under glass during the summer were more favorable than those conducted under tent cloth, both in respect to fungi and setting fruit. Our melon crop ran into October, and there was not to be seen the slightest trace of any form of blight during the whole season. The house was ventilated freely during the day time, hence allowing insects free opportunity to fertilize the flowers, as a result of which we had a superabundance of fruit. Since it was our purpose to observe what effect the absence of moisture would have upon infection, the foliage of the vines was kept entirely free from water throughout. Notwithstanding that the various blights which affect the cucumber were present everywhere out of doors, no infection took place in this crop. We are convinced that *Plasmopara* or the downy mildew (see p. 31) can be held in check in greenhouses, if the moisture conditions are controlled; and the same may hold good to some extent in the *Alternaria* and the anthracnose. At any rate, none of these fungi made their appearance on the foliage under glass. There is considerable difference in the conditions prevailing under glass from those under tent cloth. Tent cloth may succeed in keeping off dews and mists from the plants. It will, however, allow rain to pour through without much difficulty, whereas the greenhouse can be kept practically tight. In

conclusion, it may be stated that it is not generally conceded by tobacco growers who experimented with cucumbers, etc., under tent cloth, that this method of culture will be of any practical importance in the cultivation of garden crops. It is quite evident, however, that it succeeds in producing plants of better foliage, and, on the whole, it has a value in certain cases of preventing infection.

Experiments in Heating Soils.

The rather unusual interest taken in the problem of soil sterilization within the last few years has been the means of inducing growers to improvise various devices for heating soil. Some of these appliances have been constructed for personal use only, while others have been patented and placed on the market. The diameter of the tubing and method of perforating, together with the size and number of the perforations, differ much in the various appliances. The amount and pressure of steam and distance between pipes in the soil also vary with different appliances, as does the relative efficiency and cost of heating. Our experiments, which were rather limited in extent, consisted in testing the relative heating capacity of pipes one foot long and of various diameters, which contained the same number and area of perforations; also of pipes of the same diameter, containing various sizes and numbers of perforations. We made use of iron pipe, galvanized iron and tin tubing, and porous tile. In order to test their relative efficiency, we placed them in the centre of a keg that had a hole bored in the side for a thermometer, which in each case was placed about six inches from the tubes. The keg was filled with soil, and steam entered into the tube. All of the tubes except the tile were plugged at the lower end, and the steam had to penetrate the soil through the perforations. The table shows the result of these experiments: —

Table showing the Relative Heating Efficiency of Tubes of Various Diameters, Sizes, and Numbers of Perforations.

KIND OF TUBE.	Number of Perforations.	Area of Perforations (Square Inches).	Size of Perforations (Inches).	Time required to heat Soil 200 Degrees F. (Minutes).
(*a*) Two-inch iron pipe, . .	44	1.21	3/16	5
(*b*) One-inch iron pipe, . .	44	1.21	3/16	11
(*c*) Two-inch colander tin, .	4,646	14.26	1/16	2½
(*d*) Two-inch galvanized iron,	29	1.42	¼	2
(*e*) Two-inch galvanized iron,	116	1.42	⅛	3¼
(*f*) Two-inch tile, . . .	–	–	–	7½

A comparison of one-inch and two-inch iron pipes, each containing four rows, giving a total of forty-four perforations, three sixteenths of an inch in diameter, gave as a heating capacity for two-inch pipe five minutes, and for one-inch pipe eleven minutes; or, in other words, it requires six minutes longer for the one-inch pipe to heat the same mass of soil than the two-inch pipe. An average of four experiments gave for the two-inch pipe nine minutes and for the one-inch pipe seventeen minutes, or nearly the same ratio.

Two tests were made with one and one-half inch pipe, similar in every way to those just described. Since this pipe was mislaid, further experiments with it were discarded. It may be stated, however, that the results obtained by the use of this pipe were better than those with the one-inch, although not so good as those obtained by the use of the two-inch.

A comparison of the three perforated tin and galvanized iron tubes (*c*, *d* and *e*) showed little variation in heating capacity. The colander tin tubes, however, had a great many perforations, representing a much larger area for steam to escape. Notwithstanding this, it was not superior to tube *d*, which was a section of Cartter's sterilizing apparatus. The experiment with tile (*f*) was, as might have been expected, less satisfactory as a heater than any of the others except the one-inch pipe. The lower end of the tile was not closed, hence practically all the heat which escaped did

so through both ends of the tile, and only a little through the pores.

In these experiments it appears that a two-inch pipe is far superior to a one-inch pipe as a heater, where the number and size of the perforations are the same; also that for all practical purposes one-fourth-inch perforations are better than smaller ones, even where the total area is the same or even greater. It is therefore not so desirable, if efficiency is to be considered, to construct sterilizers out of one-inch iron pipe, as some have done, inasmuch as a two-inch tubing with three-sixteenths or one-fourth inch perforations will give better results. The best results were obtained with a section of Cartter's tube, which contained four rows of perforations one-fourth inch in diameter.

In heating soils there are many factors which have to be taken into consideration, such as the pressure and the amount of steam supplied, the size of the apparatus, and the amount of earth that is to be heated. These factors are so variable that probably no two men have sterilized soil at the same cost. Sterilizers that will do rapid and cheap work at a certain pressure and supply of steam will do less work at a greater cost with the same pressure and less volume of steam. It is not only essential that the sterilizer should be constructed on the best principles, but the volume of steam and pressure maintained should be adapted to the requirements.

Influence of Sterilized Soil on Seed Germination.

In previous reports and bulletins from this station there have been given results of some experiments relating to the influence of various agencies upon the germination of seeds. For some years much use has been made of sterilized soils by this division in studying the various diseases of greenhouse crops. In numerous experiments, made upon a considerably large variety of plants, we have always noticed the marked effect which sterilization had upon the germination of seeds and the subsequent growth of the plant. Many photographs have been made from time to time of those crops which display very important differences, and in some instances the weight of the plants has been recorded, which

show the marked effects that soil sterilization has upon germination and growth. We had made no experiments, however, to ascertain to what extent acceleration took place in seed germination, until the following were made, the results of which are shown in the table : —

Germination of Seeds in Sterilized and Unsterilized Soil.

Number of Experiment.	Kind of Seed.	Total Number of Seed tested.	Number germinated in — Sterilized Soil.	Number germinated in — Unsterilized Soil.	Per Cent. Gain or Loss.
Experiment 2,	Radish,	600	159	81	41
Experiment 3,	Tomato,	600	93	110	—13
Experiment 5,	Cucumber,	600	281	187	33
Experiment 10,	Lettuce,	600	26	10	61
Experiment 11,	Tomato,	600	37	33	10
Experiment 13,	Onion,	400	48	31	35
Experiment 14,	Mustard,	400	84	32	61
Experiment 15,	Turnip,	400	105	37	64
Experiment 16,	Red clover,	400	68	45	33
Experiment 17,	Onion,	200	57	32	43
Experiment 18,	Red clover,	200	83	73	12
Experiment 21,	Lettuce,	200	87	26	70

In these experiments we purposely made use of seeds representing considerable variations in age and of low germinating capacity, and where certain numbers are omitted in column 1, it should be understood that in such cases the seeds were so old that little or no germination took place. The seeds in each experiment were taken from uniform lots, *i.e.*, they were supposed to be of the same age and from the same source ; and where the same kind of seed appears twice in the table, it indicates that they are of different age and origin. Two hundred seeds were used in each experiment, one hundred being sown in sterilized soil and one hundred from the same lot in unsterilized soil. In some instances the experiment is repeated three times, in which case we have the average germination of six hundred seeds. The soil used was the same, except that one lot was sterilized, the other not. The lower the per cent. of germination

which seeds exhibit, the more important it is that a larger number should be employed in order to obtain true averages. Where seed showed 95 per cent. germinating capacity, a test including one hundred seeds is of some value. On the other hand, where there is only a germination equal to 10 per cent., a truer average can be obtained by employing eight hundred or a thousand or more, or, what is better, to repeat the experiment at least half a dozen times with a smaller number of seeds. The high percentages given are somewhat misleading, as the number of seeds used was not sufficient to obtain reliable averages. All of the experiments could be repeated to advantage. Since in many instances the seeds were used up, it was not possible to continue the experiments further. These experiments, nevertheless, possess a certain value, and the results coincide in a general way with what we have continually observed in the greenhouse. In germinating thousands of lettuce seeds in boxes we have noticed many instances similar to that shown on No. 21, although the percentage of gain is too high for average results. The average acceleration given in all of the experiments shown in the table, or the percentage of germination noted on the fourth day after planting, was 25 per cent. in favor of the sterilized soil. It will be noticed that the tomato seeds do not respond to sterilized soil, and in four out of seven tests those growing on unsterilized soil gave the best results. Since these experiments are preliminary ones, and are being continued, further comments at this time are not necessary, except to relate that from an economic point of view we consider it worth while to start such plants as lettuce, cucumbers, melons, tobacco, etc., in sterilized soil, provided steam is available. In such cases the expense would be very insignificant. Besides returns from acceleration and increase in germinating capacity, the important factor of immunity from diseases such as those arising from the damping fungus, etc., is important.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The work of the meteorological division of this station during the past year has been much the same as outlined in previous reports. The abnormal temperature conditions prevailing during much of the growing season caused more than the usual interest in the monthly bulletins issued, and in abstracts from them published by a considerable number of the papers of the State.

At the end of June, Miss S. C. Snell, the voluntary observer for the United States Weather Bureau, resigned after a service of more than twenty-five years. At the request of Mr. J. W. Smith, section director, the station has arranged to furnish the temperature and precipitation records on the voluntary observer blanks, in addition to the records published in the monthly bulletin. All records for Amherst now published in the monthly report of the New England section of the climate and service of the Weather Bureau are now credited to the Hatch Experiment Station, instead of only the barometer and wind records, as formerly. Arrangements have been made to furnish the weekly snow reports to the Boston office the present winter, as heretofore.

The local forecasts for the weather of the following day have been furnished daily, except Sunday, as in former years. Their transmission to the college by telegraph has been less satisfactory than formerly, owing to the interference of the electric currents of the local electric railways. If our telegraph line from the Western Union office to the tower could be relocated, so as to avoid this interference, the forecasts could be received more certainly and promptly.

The monthly observations of the declination of the mag-

netic needle have been made, as indicated in last year's report. The laying of steam pipe to the several buildings during the summer has probably affected the results of the last few months. Pending a more complete report of these results, it may be stated that the mean declination for 1900 was 11° 10′ west; for 1901, 11° 10′ west; and for the present year, 11° 14′ west.

The equipment has remained practically the same during the year. In the near future a number of new clocks for some of the self-recording instruments will be required.

At the close of the college year, in June, Mr. H. L. Bodfish, the observer, retired from the division, and was succeeded by the assistant observer, Mr. S. C. Bacon.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

During the year 1902 the work of the entomological division has been concentrated along a few but important lines. The correspondence has, as usual, occupied much time, and a large portion has been of a routine nature. This part of the work is of great importance, and it has been the intention to give the most careful attention to every letter received, however common the insect concerned may be, as the greatest amount of assistance is often needed in order to effectively combat the most common forms.

Extensive experiments on the best methods of treatment for the San José scale under New England conditions have been carried on in the college orchard during the year. Over six hundred trees have been treated in different ways, and the results studied by means of repeated inspections during the summer and fall. A discussion of this work and its results thus far is now being prepared for publication as a station bulletin.

Much attention has also been given to the preparation of the early stages of insects for the insectary collection. As in most cases the injuries caused by insects are while the latter are immature, the importance of representing all stages in a collection at once becomes evident. In connection with the additions thus made, an extensive rearrangement of the collection has been begun, the result of which will be to make it more instructive and available for direct study and comparison than ever before. Many records and life histories have also been added to the insectary files.

Work on the card catalogue, referred to in previous reports, has been continued, and the value of the catalogue as

a whole is demonstrated by its frequent use each day. From it a bibliographical catalogue of the scale insects of the world has been prepared, and is ready for the printer.

The nursery inspection law, passed by the Legislature of 1902, has removed the work of nursery inspections from the list of duties of the entomological division of the station; but the appointment of the associate entomologist of the station as inspector has enabled him to make the service of the station available to many who were not previously aware of the opportunities it offers for assistance in difficulties they meet, and it has also enabled him to learn more of the entomological problems which need investigation in the State than could possibly have otherwise been the case.

Insects of the Year.

No serious insect outbreaks have been observed during the year, though many kinds have made their presence felt.

The brown-tail moth has continued to spread, and in the more central portion of its distribution has become extremely abundant. So serious is it in some places that city and town authorities have taken up the work of gathering and destroying the tents during the winter months, as a partial method of relief from the sufferings which would otherwise be caused from the irritation on the human skin produced by the hairs of this insect during the following summer months. A bulletin has been prepared on this insect, and published by the State Board of Agriculture.

The gypsy moth has increased in numbers, until in some places it is nearly as abundant as it has ever been. In general, however, it has not as yet made its presence seriously felt, though a year or two more is all that will be necessary for it to fully re-establish itself throughout its original territory.

The San José scale is now present in over one hundred cities and towns, and is rapidly spreading, though fortunately the number of food plants on which it thrives so as to endanger the life of the plant appears to be small. During the fall it was found on California privet, arbor-vitæ and

spruce,— food plants not heretofore reported, though whether it can live for any length of time on these remains to be seen.

The elm-leaf beetle has attracted but little attention this year, except in the north-eastern part of the State, where it has appeared in abundance for the first time. Elsewhere it was about as plenty as usual, and was generally treated by the tree wardens and city foresters with considerable success. It has now been established that in the Connecticut valley this insect has but a partial second brood, — so small, in fact, that the injury it causes is almost infinitesimal.

The resplendent shield-bearer (*Aspidisca splendoriferella*) has been abundant, attacking the apple leaves, but appears to have caused but a small loss. The apple-leaf miner (*Tischeria malifoliella*) appeared in abundance in apple leaves in the fall of 1901, and was present in large numbers last spring. Careful studies on this insect show that in Massachusetts it is two-brooded, the adults appearing in early spring and also in July.

Two species of *Aleyrodes* have been doing a great deal of damage in some parts of this State, — one in greenhouses, the other out of doors on strawberries and other plants. These species have long been considered identical with *Aleyrodes vaporariorum* Westw., a common European insect, but the one on strawberries proves to be a new species. Both have been very carefully studied here, and the new one described and published with illustrations in the Canadian "Entomologist," under the name of *Aleyrodes packardi*. The studies on the other species will be published with illustrations as soon as completed.

The life histories of several bugs have also been worked out, and are now in the printer's hands for publication.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Assistants: E. B. HOLLAND, P. H. SMITH, J. W. KELLOGG,[1] T. M. CARPENTER.[1]
Inspector of Babcock Machines and Dairy Tester: N. J. HUNTING.
In Charge of Feeding Experiments: ABEL GILBERT.
Stenographer: MABEL SMITH.

PART I. — OUTLINE OF YEAR'S WORK.

- A. Correspondence.
- B. Extent of chemical work.
- C. Character of chemical work.
  - (*a*) Water.
  - (*b*) Dairy products and feed stuffs.
  - (*c*) Chemical investigation.
- D. Cattle feed inspection.
- E. Execution of the dairy law.

PART II. — DAIRY AND FEEDING EXPERIMENTS.

- A. Tests of pure-bred cows.
- B. Tests of fly preventives.
- C. Summer forage crops.
- D. The pentosans.
- E. Digestion experiments with sheep, 1894–1902.

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[1] During the year Messrs. Kellogg and Carpenter severed their connection with this division, to accept more lucrative positions elsewhere, the former going to the Rhode Island and the latter to the Pennsylvania Experiment Station. The loss of these two efficient workers has been seriously felt, and naturally impeded the work of the division.

Part I. — Outline of Year's Work.

J. B. LINDSEY.

A. Correspondence.

The correspondence of this division was about the same in character and amount as in preceding years. Information is asked on a great variety of subjects. Some questions can be easily answered by reference to bulletins already published, while others require considerable thought and study. The total number of letters sent out during the year has been 1,950.

B. Extent of Chemical Work.

The work in the chemical laboratory has been similar to that of previous years. The large amount of routine work in connection with the examination of water, milk, cream, butter, feed stuffs and miscellaneous substances leaves little time available for strictly chemical investigation. The amount of chemical work may be better understood by noting the variety and number of substances recorded below.

There have been sent in for examination 181 samples of water, 120 of milk, 1,482 of cream, 118 of pure and process butter, 9 of oleomargarine, 130 of feed stuffs and 9 of miscellaneous substances. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 187 samples of milk and cream, 42 of butter fat and 642 of fodders and feed stuffs. There have also been collected, under the provision of the feed law, and tested, either individually or in composite, 320 samples of concentrated feed stuffs. This makes a total of 3,240 substances analyzed during the year, as

against 3,622 last year and 3,036 in the previous year. Work on pentosans, fiber, starch, sugar and fat, and on the availability of organic nitrogen, not included in the above, has been done for the Association of Official Agricultural Chemists. In addition, 13 candidates have been examined and given certificates to operate Babcock machines in creameries and milk depots, and 2,344 pieces of glassware have been tested for accuracy.

C. Character of Chemical Work.

(*a*) *Water.*

This division during the past year has endeavored to make sanitary analyses of drinking water, so far as time and means would permit. Samples were received not only from farmers, but from persons following various trades and professions. They were practically all from wells, springs and ponds, in towns not provided with a public water supply. A few were of excellent quality, many of fair quality only, others quite suspicious, while some were entirely unfit for use. A number of samples were found to contain lead, due to the use of lead pipe. Drinking water thus polluted results in serious cases of lead poisoning. All parties are *cautioned never to use lead pipe to conduct water intended for drinking or cooking purposes.*

It has been the custom, ever since the establishment of the Massachusetts Experiment Station, in 1882, to make sanitary analyses of drinking water free of cost to citizens of Massachusetts. Because of the increase of other lines of work, and the limited funds available, it has become necessary to make a small charge for each sample of water examined. Acting under instructions from the Experiment Station committee, the following regulations have been adopted: —

After Jan. 1, 1903, there will be a charge of three dollars for each sample of water tested at this station. This charge is intended to simply cover the cost of the chemist's time and the gas and chemicals employed in the examination. Heretofore, to aid in promoting the public health, sanitary analyses of drinking water have been made free of cost to citizens of Massachusetts, although the station has in no way been required by law

to do so. The increase of other important lines of work now severely taxes the limited resources of this division, and renders such a step necessary.

Those wishing to secure a sanitary analysis of water must first apply, whereupon a glass bottle securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express. The return expressage must in all cases be prepaid. Because of the smallness of the sum involved, no account will be opened. Remittance by check, P. O. money order, or money at the owner's risk, must be strictly in advance.

Application may be made and money sent to

Dr. J. B. Lindsey,
Hatch Experiment Station.

(*b*) *Dairy Products and Feed Stuffs.*

Slightly less than the usual number of samples of milk and cream were received during the past year. They were sent largely for the purpose of ascertaining their butter fat content. Some farmers wish to ascertain the quality of milk produced by their animals, while others who sell cream wish to check the work of the local creamery. Oftentimes samples are received from milk dealers whose product has been found below the legal standard; in such cases, both total solid matter and fat are determined. Printed circulars are sent to all inquiries, giving concise information concerning the quality of milk produced by different breeds, as well as full instruction relative to the best methods to be employed in determining the butter-producing capacity of dairy herds.

This division also examines milk, cream, butter and oleomargarine collected by the agent of the Dairy Bureau in western Massachusetts. The past year the work has been confined almost wholly to the examination of renovated butter. The number of feed stuffs received was somewhat in excess of those received a year ago. In some cases a physical inspection only was necessary, while in other cases both a chemical and microscopic examination are required. Numerous samples are received from wholesale dealers, who avail themselves of the station facilities to make sure that the materials they are offering are as represented. It is the intention to give such samples immediate attention, and to return the results promptly.

(*c*) *Chemical Investigation.*

It is the aim of this division to devote as much attention as possible to chemical investigation, in connection with the many dairy and feeding problems. The very limited time at our disposal the past year has been given: (*a*) to the examination of butter fat in connection with feeding experiments, to note the effect of various feed constituents upon its character; (*b*) to the improvement of methods for the determination of the pentosans and starch in feed stuffs; and (*c*) to the determination of the availability of organic nitrogen in fertilizing materials. An inquiry was also conducted to ascertain the effect of two different milk-condensing processes on the nitrogenous bodies of milk.

A great deal of time has also been given to chemical work in connection with the various feeding and dairy experiments. Some of the experiments, being completed, are reported in Part II., while others are still in progress.

D. Cattle Feed Inspection.

During the past year only one complete canvass of the State has been made for the purpose of collecting samples of concentrated feeds; heretofore, at least two inspections were made yearly. More work had been done, however, along this line in the past than the small amount of money available under the law would admit; hence the necessary curtailment. The results of the samples collected and examined for 1901 were published in Bulletin No. 78, of which 9,000 copies were issued. A quite thorough inspection was made in October and November, 1902, and the feeds are now undergoing a chemical and microscopic examination. It may be said that, owing to the unusually open autumn, and because of the expectation that with the advent of new corn the prices of feeds would generally reach a lower level, dealers were carrying light stocks. Little new cotton-seed meal had arrived, and the various gluten products were in light supply. West of the Connecticut River very little material, excepting wheat feeds, was found. As soon as the weather becomes colder, and especially after the new crop

of corn becomes available, the quantity and variety of feed stuffs must be greatly increased.

In general, it may be said that the better grades of concentrated feeds, such as cotton-seed meal, linseed meal, the gluten and unmixed wheat products, are practically free from adulteration. Exceptions to this statement are to be found in the frequent admixture of wheat screenings with wheat bran, and in an entire car of so-called "Fancy Canada Bran," containing a very large admixture of coffee hulls, — a worthless feeding material.

Mixed feed, a trade name for a mixture of 1,200 to 1,800 pounds of wheat bran and 200 to 800 pounds of fine middlings and "red dog," is often seriously adulterated by substituting ground corn cobs or broom-corn waste for the middlings. This falsification is not practised by reputable millers, but by unscrupulous outside parties, or possibly by small millers in remote localities. It is hardly necessary to remark that this material is sold at the same price as the genuine. A considerable variety of oat offal is always in the market, and in some cases it is guaranteed to contain a noticeably higher percentage of protein than is shown by analysis. The manufacturers' attention has been called to this misrepresentation, but they do not choose to rectify it. A large amount of so-called provender consists of mixtures of oat offal and cracked corn in place of ground oats and corn. It is believed that this deception is increasing. The larger part of the oat offal in the market is sold at prices much in advance of its value.

Among the new feeds in the market the past year may be mentioned dried distillers' grains, — the residue in the manufacture of alcohol, spirits and whiskey, from the several cereals; and nutrene dairy feed. This latter product is made in Louisiana, and consists of cheap molasses soaked up in oat clippings or similar material, with the addition of a little cotton-seed meal, hulls, etc. Its exact value is at present uncertain.

Attention was called in the last report to the need of a new feed law, and the reasons therefor made as explicit as possible. This need cannot be too strongly emphasized at

the present time. A bill has been prepared for presentation at the coming session of the Legislature, and it is hoped it will receive the cordial support of all consumers, as well as reputable manufacturers and dealers.

E. Execution of the Dairy Law.

The text of the law (chapter 202, Acts of 1901) may be found in the report of this station for 1901, page 156. The law naturally resolves itself into three sections: (1) the testing of Babcock glassware for accuracy of graduation; (2) the examination of candidates for proficiency in operating the test; (3) the inspection of Babcock machines.

Inspection of Glassware. — All glassware found to be correct is marked "Mass. Ex. St.," by means of a sand blast. During the first year it was necessary to inspect the ware in use by all creameries and milk depots employing the test; now practically all is received from supply houses that keep tested ware in stock. The total number of pieces examined the present year has been 2,344, of which 56 pieces, or 2.4 per cent., were found incorrect. A year ago 5 per cent. were found improperly graduated. Manufacturers are now very careful concerning the accuracy of their product.

In testing glassware, the following limits of error are allowed: —

	Capacity.	Single Graduation.	Limit of Error.
	Per Cent.	Per Cent.	Per Cent.
Cream bottles, Connecticut,	30–35–40	.50	.50
Cream bottles, Connecticut,	50	1.00	.50
Cream bottles, Bartlett,	25	.20	.20
Milk bottles, common,	10	.20	.20
Milk bottles, Ohlsson,	5	.10	.10
Milk bottles, Wagner,	8	.10	.10
Skim milk bottles, double quantity,	2.00	.10	.10
Skim milk bottles, Ohlsson,	.50	.05	.02
Skim milk bottles, improved Ohlsson,	.25	.01	.01
Skim milk bottles, Wagner,	.50	.05	.02
Skim milk bottles, improved Wagner,	.25	.01	.01
	Cubic Centimetre.	Cubic Centimetre.	Cubic Centimetre.
Pipettes, cream,	18.00	-	.10
Pipettes, milk,	17.60	-	.10
Acid measures,	17.50	-	.20

Examination of Candidates. — Mr. E. B. Holland has taken charge of this work. Last year 45 candidates were examined, being principally the operators in the employ of Massachusetts creameries and milk depots. The present year 13 were examined and given certificates of competency. It is believed that practically all now using the Babcock test as a basis for payment have a good understanding of the process, and are capable of doing satisfactory work.

Inspection of Babcock Machines. — The examination of Babcock machines has been in charge of Mr. N. J. Hunting, who visited each creamery or milk depot, and made a personal inspection of all machines in use. At the time of presenting the last report it was not possible to state the results of the first inspection (1901), which showed 20 machines to be in good condition, 11 to be in need of repairs and 9 to be entirely unfit for satisfactory work. A number of machines needed levelling, and several were without a steam gauge or speed indicator. The condition of a machine frequently depends upon the operator. If he is careful and painstaking in his work, the tester is likely to be found in good repair. The total cost of the first inspection was $182.42, — $4.56 each. It was impossible to exactly apportion the cost of examining each machine, so that it seemed wiser to divide the total cost of inspection by the number of machines examined, the quotient being the cost to each creamery. It became necessary, because of the number of machines out of condition or condemned, to make a second inspection, the cost of which was apportioned as equally as possible among those directly interested. A few managers considered the cost excessive, but it was not possible to do the work for less. Simply because one-half or one hour was occupied in making the actual examination, it must not be understood that the charge should be only for the time thus employed. The entire cost covers the time actually spent en route, including occasional delays, as well as travelling and hotel expense. The proper enforcement of this law has required the expenditure of a great deal of time on the part of the employees of this division

without any financial return. The extra labor has been cheerfully given, however, with a belief that it has resulted in positive good to both creameries and patrons.

The inspection for 1902 is in progress at this writing (December 10). The inspector states that he finds nearly all machines now in good working condition, the improvement over last year being quite marked.

It is evident that the creamery law has been of direct benefit to the creameries of the State. It has decidedly improved the accuracy of Babcock glassware, taught many operators to be more careful in making the test, given the majority a better understanding of the principles involved, caused many Babcock machines to be put in proper condition to do accurate work, and replaced worn and antiquated machines with those of modern construction. The total expense to each creamery and indirectly to each patron has been merely nominal.

Part II. — Dairy and Feeding Experiments.

J. B. LINDSEY.

A. Tests of Pure-bred Cows.

During the past year this division has made the following milk, butter fat and butter tests for the several cattle associations, in accordance with their prescribed rules: —

Five cows were tested for the Holstein-Friesian Association, to ascertain the amount of milk and butter fat produced during seven consecutive days.

Nine cows are now being tested for the American Guernsey Cattle Club. The amount of milk and butter fat produced in one day of each month is ascertained, and upon this is based the monthly yield.

Two cows are now undergoing a yearly milk and butter fat test for the American Jersey Cattle Club. The amount of milk and fat produced during two consecutive days of each month is ascertained, and upon this product is based the monthly yield.

The tests are all made at the farms of the several owners, by or under the supervision of a representative of this station.

The results of the following confirmed tests, made at the request of the American Jersey Cattle Club, for Mr. C. I. Hood of Lowell, Mass., are sufficiently instructive to warrant their presentation in this report: —

Confirmed Butter Tests at Hood Farm.

Milk produced (Pounds).	Per Cent. Fat in Milk.	Butter Fat produced (Pounds).	Equal to 85 Per Cent. Butter.		Butter churned.		Fat lost in Skim Milk and Buttermilk, etc. (Pounds).	Fat available for Butter (Pounds).	Fat recovered in Butter (Pounds).
			Pounds.	Ounces.	Pounds.	Ounces.			
Elsie Wolcott.									
258.12	4.96	12.81	15	1	14	10	.207	12.60	12.31
Betsona Khedive La Gros.									
282.00	5.49	15.50	18	4	17	10½	.227	15.27	14.92
Figgis.									
293.44	5.48	16.08	18	15	19	½	.160	15.92	15.85
Sophie Tenth.									
278.06	4.59	12.77	15	–	15	5½	.160	12.61	12.72
Oonan Eighth.									
211.70	5.94	12.58	14	13	14	10½	.109[1]	12.47	12.10
Brown Bessie Forty-Sixth.									
210.38	5.42	11.41	13	7	13	8½	.171	11.24	11.16
Nora of Argyle.									
276.44	5.30	14.65	17	4	16	13	.216	14.43	14.25
Oonan Fourteenth.									
287.56	4.42	12.71	15	–	15	3	.308	12.40	12.41
Hood Farm Belle.									
260.31	4.66	12.13	14	–	14	2	.221	11.91	11.41
Oonan Seventh.									
289.20	4.41	12.74	15	–	14	2½	.820[2]	11.92	11.46

[1] Fat in buttermilk not included. [2] Buttermilk contained 1.4 per cent. of fat.

The first three columns show the total milk produced in seven days, the average per cent. of fat it contained, and the pounds of butter fat actually produced by each animal.

The fourth column indicates the equivalent of this butter fat in 85 per cent. butter, and the fifth column shows the amount of butter actually churned. There are no wide variations between estimated and actual butter,[1] which means that the butter was of normal composition.

The sixth column, entitled "Fat lost," etc., means the entire amount of fat contained in the skim milk and buttermilk, and in the milk used in Babcocking. The average per cent. of fat in the skim milk was .031 per cent., and in the buttermilk (excepting Oonan Seventh), .061 per cent. In only two cases did the buttermilk show .15 or more per cent. of fat.

The seventh column shows the fat available for butter, and is obtained by deducting the fat lost in the manufacturing process from the entire quantity of fat produced.

The eighth column contains the quantity of fat actually recovered in the butter, as ascertained by chemical analysis. Theoretically, the seventh and eighth columns should agree. In five out of the ten results this is practically the case; the other five show discrepancies, which must be charged to errors in manipulation. The differences in case of Hood Farm Belle and Oonan Seventh are excessive. Of the 133.38 pounds of fat produced by the ten animals, 128.59 pounds, or 96.41 per cent., were recovered in the butter, showing a loss of 3.59 per cent. in the entire manufacturing process.

The butter was made by the regular Hood farm butter maker. Samples of each lot were taken at once by the tester, and sent to the Experiment Station for analysis. In six cases two lots of butter were made from the cream produced in seven days, and in four cases the entire cream produced during the period was churned at one time. The following table gives the analysis of the butter made from the fat produced by each animal: —

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[1] There is one exception in case of Oonan Seventh, due to the loss of considerable fat in the buttermilk.

Analyses of Butter.

CONSTITUENTS.	Elsie Wolcott.	Betsona.	Figgis.	Sophie Tenth.	Oonan Eighth.	Brown Bessie Forty-sixth.	Nora of Argyle.	Oonan Fourth.	Hood Farm Belle.	Oonan Seventh.
Water,	11.45	11.74	14.36	13.98	15.37	13.56	12.37	13.28	16.23	14.45
	14.27	14.24	13.30		14.35	14.63		16.91		
Fat,	86.37	85.34	82.87	82.98	82.23	83.27	84.82	83.81	80.75	81.00
	81.80	83.40	83.96		82.55	82.00		78.98		
Salt,	1.38	2.01	1.98	2.28	2.00	2.49	1.91	2.24	2.76	3.39
	3.13	1.70	1.87		4.00	2.60		3.39		
Curd,	.80	.91	.79	.76	.40	.68	.90	.67	.26	1.16
	.80	.66	.87		.70	.77		.72		

The extremes in the percentage of butter fat were 78.98 and 86.37 per cent., and in the percentage of water, salt and curd, 13.63 and 21.02. The average composition of the 16 samples was: water, 14.03 per cent.; fat, 82.88; salt, 2.45; and curd, .74.

The Babcock machine in the hands of the tester has shown how much butter fat the cow has actually produced, and how much has been lost in the process of manufacturing the same into butter. The chemist has demonstrated the amount of butter fat actually recovered in the form of butter, and his results in eight out of the ten cows closely agree with those obtained by the Babcock machine (total butter fat produced minus fat lost). The chemist further gives evidence that the butter produced, while it varied somewhat in composition, was of normal character.

It is clear from the above data that the amount of butter fat produced by the cow furnishes, to say the least, accurate and consequently satisfactory evidence of her butter-producing capacity.

The results, taken as a whole, reflect much credit upon the work done by the testers and butter maker.[1]

[1] These confirmed tests were made by Messrs. F. R. Church, W. A. Conant, E. S. Fulton and B. Tupper. In each case the work was very carefully done.

B. Tests of Fly Preventives.

For the past two years this division has made a trial of a number of so-called fly removers. These materials are generally sold at retail for from one to one and one-half dollars a gallon. No effort was made to ascertain the exact composition of each. They appeared to consist largely of some oil such as crude petroleum, to which more or less pine tar had been added. In one case fish oil was noticed, and in another light coal tar oil. When not too thick, they were applied with a Woodason or Aspinwall sprayer; otherwise, a four-inch varnish brush, dipped in the liquid, was very lightly drawn over the animals. The latter method is less satisfactory, for the reason that it is hardly possible to avoid putting on an excess; in which case it forms a sticky mass with the hair, to which the dust adheres, giving the animals a very untidy appearance.

Brands and Manufacturers.

Brand.	Manufacturer.	Location.
1. Sure Thing, . . .	Empire State Shaft Coupling Company.	Utica, N. Y.
2. Cattle Comfort, . .	Hammond Slug Shot Works, . .	Fishkill, N. Y.
3. Stop Fly, ...	Standard Oil Company, . . .	New York, N. Y.
4. Norwood Sanitary Fluid,	Smith, Kleine & French Company, .	Philadelphia, Pa.
5. Flylene, ...	American Glucose Works, . .	Camden, N. Y.
6. Shoo Fly, ...	Shoo Fly Manufacturing Company,	Philadelphia, Pa.
7. Eli Fly Chaser, . .	Vail Seed Company, ...	Indianapolis, Ind.
8. Eureka, ...	J. H. Ames Company, . . .	Bowdoinham, Me.
9. Rippley's Fly Remover, .	Rippley Hardware Company, . .	Grafton, Ill.
10. Cyphers Anti-fly Pest, .	Cyphers Incubator Company, . .	Boston, Mass.

Results with Cows.

The cows were treated in the morning before being turned out in the yard, and again at night before milking. They were observed at frequent intervals during the day, in order to note the effect of each particular brand.

1. *Sure Thing.* — Applied as spray. Keeps off flies for a short time, but not lasting in its effects.

2. *Cattle Comfort.* — Applied as spray. Not very satisfactory.

3. *Stop Fly.* — Applied as spray. Favorable effect disappeared in one-half hour.

4. *Norwood Sanitary Fluid.* — Applied as spray. This material is unquestionably crude creolin; it is very valuable as a disinfectant, but not satisfactory as a fly remover.

5. *Flylene.* — Very effective, keeping the flies off for a long time.

6. *Shoo Fly.* — Applied with brush. It was fairly effective in keeping off small flies, but not the large house fly.

7. *Eli Fly Chaser.* — Applied with brush. Same as No. 6.

8. *Eureka.* — Fairly satisfactory. Weather cool, and trial consequently not as thorough as others.

9. *Rippley's Fly Remover.* — Keeps small flies off for a short time. One year's trial.

10. *Cyphers.* — Keeps flies off for a short time. Only one year's trial.

Tests with Other Substances.

11. *Light Coal Tar Oil.* — This is the lighter of the two oils derived from tar. It was obtained through the courtesy of the Pocahontas Collieries Company, Pocahontas, Va. It appears as a dark, thin oil, with a strong creosote odor. It was applied as a spray, and gave quite satisfactory results.

12. *Recommended by J. M. W. Kitchen, M.D.* — One pound resin, one-half pound caustic potash, two pounds whale oil soap (chipped), two quarts water. Boil these until all united into a smooth liquid, then add one pound pine tar and one pint kerosene. Thin down if necessary with water and kerosene. This mixture was quite thick and heavy. It was applied lightly with a brush, but was not effective.

13. *Recommended.* — One-half tea cup bi-sulphide carbon, in which dissolve one tablespoonful pine tar, stirring thoroughly until tar is dissolved, and then add one quart kerosene or crude petroleum, and apply as a spray. This mixture was quite effective for a few hours, until the carbon bi-sulphide had evaporated. It must be kept in glass-stoppered bottles.

Results with Horses.

The agricultural division of this station gave a number of these articles a test with work horses, applying the same with an Aspinwall sprayer.

1. *Sure Thing.* — Keeps flies off well for about five hours; the large green fly does not mind it. Gums horse some.

2. *Cattle Comfort.* — Lasts about three-fourths of a day. Gums horses.

3. *Stop Fly.* — Ineffective.

4. *Norwood Sanitary Fluid.* — Ineffective.

5. *Flylene.* — Keeps flies off well, and gums horses but little. Very satisfactory.

6. *Eli Fly Chaser.* — Quite satisfactory, and equal to No. 5. Does not gum badly.

7. *Eureka.* — Same as No. 6.

8. *Cyphers.* — Protects for short time only and gums badly.

General Conclusions.

(*a*) Quite satisfactory: 1. Flylene; 2. Eureka; 3. Eli Fly Chaser; 4. Shoo Fly; 5. Light coal tar oil.

(*b*) Less satisfactory: 1. Sure Thing; 2. Cattle Comfort; 3. Rippley's Fly Remover; 4. Cyphers Anti-fly pest; 5. Recommended mixture No. 13.

(*c*) Unsatisfactory: 1. Norwood Sanitary Fluid; 2. Stop Fly; 3. Recommended mixture No. 12.

The only objection to those marked "quite satisfactory" is their cost. It is hoped that we shall be able to find some cheaper and equally effective substance or mixture. The most promising substance is the light coal tar oil. Even at the present cost of the commercial articles, it is believed their use is warranted, because cows remain much quieter, and horses work better and require less attention from the driver.

C. Summer Forage Crops.

(*a*) *Winter Wheat and Sand or Hairy Vetch.*

This mixture of a non-legume and legume has been tried for a number of years at the station, and has proved to be an early and desirable spring green fodder. The only ob-

jection is to be found in the present cost of the vetch seed, — $5 or more a bushel. This excessive cost is due to the fact that the vetch is a poor seeder, and frequently sheds its seeds before they can be harvested.

History of the Several Trials. — The first planting of this mixture, Aug. 1, 1898, winter-killed, in all probability, owing to the fact that the seed was sown too early.

The second planting, made Aug. 25, 1899, in the proportion of 2 bushels of wheat to 1½ bushels of vetch, wintered well, and made a fine spring growth. Cutting began May 31, and the yield was at the rate of 10 tons to the acre.

The third planting was made Aug. 24, 1900, with equal quantities of wheat and vetch seed. The autumn of that year was extremely dry, and the wheat killed out to some extent, so that the vetch predominated. The following spring was wet and cold, — a condition which appeared to favor the growth of the vetch at the expense of the wheat. At the time of cutting, May 30, the vetch had completely covered the wheat in spots, and had lodged badly. The vetch roots were full of the characteristic nodules. The weight of the entire yield was not obtained, but a conservative estimate places it at 6 to 7 tons to the acre.

The fourth planting (⅓ acre), made Sept. 3, 1901, at the rate of 1½ bushels of Rural New Yorker No. 6 wheat and 1 bushel of vetch to the acre, wintered well, and cutting began May 28, at which time the mixture was from 2½ to 3 feet high. At that time the wheat was about ready to show the head, and scattered vetch blossoms were noticed. When in full bloom the mixture stood from 3½ to 4 feet high. The total yield was 6,545 pounds, equivalent to 9.5 tons to the acre.

Further Use of the Land. — Immediately after the removal of this crop the land was ploughed, a light dressing of manure applied, and seeded with Longfellow corn. A yield (the past season) of 35,362 pounds (17.68 tons) of fairly well-eared green fodder to the acre was secured. The land was light and the rainfall excessive, which conditions were favorable, excepting lack of heat, for fodder production. The total product of this piece of land for one year (first sown to wheat and vetch, and followed by corn) was at the rate

of 8,622 pounds of dry matter to the acre, being equivalent to fully 5 tons of well-cured hay. It is not to be expected that such quantities could be obtained yearly under average conditions, for the land could not be as fully utilized. It is interesting to note, however, the quantity of fodder that may be secured from an acre of land in an average state of fertility, when climatic conditions are favorable and the land is occupied the entire season.

Best Method of growing Wheat and Vetch. — The land should be ploughed, harrowed if necessary, manure spread at the rate of 4 to 6 cords to the acre,[1] harrowed in; a mixture of 1½ bushels of wheat and 1 bushel of vetch sown broadcast about September 1, and covered, not too deeply with a wheel or other harrow. Cutting should begin just before the wheat heads appear, which in this locality is the last of May. The green crop will remain in feeding condition for twelve to fourteen days. If more of the fodder mixture has been produced than can be fed green, the balance may be made into hay. The vetch seed may be procured of New York seedsmen.

Composition of Wheat and Vetch.

Constituents.	Green Fodder.		Dried Fodder.	
	No. 1.	No. 2.	No. 1.	No. 2.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Water,	83.40	79.60	11.90	13.70
Ash,	1.50	1.76	7.97	5.22
Protein,	3.25	3.14	17.07	10.93
Fibre,	5.13	5.98	28.38	29.51
Extract matter,	6.24	8.92	32.52	38.70
Fat,	.48	.60	2.16	1.94
	100.00	100.00	100.00	100.00

The percentage of protein in the mixture is dependent to an extent upon the quantity of vetch present. In case of

[1] Fertilizer may be used in place of manure, at the rate of 50 pounds of nitrate of soda, 300 pounds of acid phosphate and 200 pounds of muriate of potash to the acre. In the spring a top-dressing of 50 to 100 pounds of nitrate of soda will prove beneficial.

sample No. 1 of both the green and dry fodder, the vetch predominated. In case of sample No. 2 of the dry fodder, the wheat was probably in excess. In fodder combinations it is difficult to secure an even distribution of the several plants. The mixture of 1½ bushels of wheat and 1 bushel of vetch per acre is satisfactory, does not lodge, and will show from 12 to 15 per cent. of protein in a thoroughly air-dry condition.

Digestibility of Winter Wheat and Sand Vetch. — Five digestion trials have been made with two different samples of green fodder, and six trials with two samples of the dried material : —

Series.	Fodders.	Number of Trials.	Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Extract Matter (Per Cent.).	Fat. (Per Cent.).
VI.	Wheat and vetch (green),	3	67.54	42.47	76.27	66.05	71.13	55.65
VII.	Wheat and vetch (green),	2	70.13	43.59	70.92	70.50	75.05	57.92
	Average,	5	68.58	42.92	74.13	67.83	72.70	56.56
VII.	Wheat and vetch (dry), same as Series VI. (green).	3	68.33	59.41	76.86	64.47	69.71	63.46
VII.	Wheat and vetch (dry),	3	64.50	35.20	70.77	64.59	66.75	63.75
	Average,	6	66.42	47.31	73.82	64.53	68.23	63.61
	Dent fodder corn (milk), for comparison.	9	70.00	–	61.00	64.00	76.00	78.00
	Oats and peas (bloom), for comparison.	5	70.00	49.00	74.00	64.00	72.00	64.00

The several digestion trials make it clear that the wheat and vetch mixture is as digestible as either fodder corn or oat and pea fodder. They also show this fodder when dried under normal conditions to be as digestible as when fed green.

General Conclusions.

1. Wheat and sand vetch is a hardy fodder mixture.

2. When sown the previous autumn, it will be ready to cut the last of May, and is considered preferable to rye.

3. It will yield about 10 tons of green material to the acre under average conditions, and in composition, digestibility and feeding value it fully equals peas and oats and similar crops.

4. Because of the present cost of vetch seed, it is doubtful if the ordinary dairyman can afford to grow it; but the milk producer in the vicinity of profitable markets, who cultivates intensively, may find it a satisfactory source of early green feed.

5. Wheat seeded by itself in early September makes a fairly satisfactory early soiling crop, and is to be preferred to rye.

6. The dried wheat and vetch fodder if cut when in bloom is preferable to ordinary hay for milk, but, on account of the increased cost of production, it would hardly be considered profitable as a hay substitute.

(*b*) *Corn and Soy Beans.*

Attention has already been called (in Bulletin No. 72) to the value of this fodder combination for August and September soiling. The present season about one-third of an acre was grown. In early September the beans were podding and the corn was fairly well eared, but the ears were only partially developed. The mixture was cut and bound successfully October 4, with the Deering corn harvester, at which time the bean stalks were quite tough, the bean pods filled and the corn kernels glazed. This is the first attempt made to cut the corn and bean mixture with a harvester. A larger area will be planted another season, in order to see if the mixture can be economically handled for silage.

Corn and soy bean silage was grown and used at this station during 1895 and 1896. At that time the corn and beans were grown in separate fields. The silo was filled in the proportion of two-thirds corn and one-third beans. The silage was satisfactory, eaten clean, and furnished 30 per cent. more protein than did corn silage. It was believed at the time, however, that the increased cost of handling the two crops when grown separately more than counterbalanced the value of the additional protein secured. If it proves economical to grow and handle the two together, it will in a measure aid in increasing the supply of home-grown protein.

(c) *Soy Beans v. Cow Peas.*

Much is being said in the agricultural press concerning the home production of protein, and this division receives frequent inquiries concerning the relative merits of soy beans and cow peas for this purpose.[1]

During the past season the following varieties of cow peas were tested: Whippoorwill, Black, Extra Early Black and Warren. Although seeded the first of June, they grew but little until late in July, the unusually cool season being decidedly unfavorable to their development. The Whippoorwill and Black produced a few blossoms early in September. The former yielded about 5 and the latter 7 tons of green fodder to the acre. The seed of the Whippoorwill did not come up as well as did the Black.

The Extra Early Black seeded fully in September, but the growth was not sufficient to warrant its use for green feed.

The Warren blossomed some, but did not grow to sufficient size to be suitable for forage purposes.

The Whippoorwill and the Black are probably the best suited to northern conditions.

In comparing the relative merits of the two legumes, it may be said that the stem of the cow pea is softer than that of the soy bean, and that the crop does its best in very warm weather, and is likely to succeed better than the soy bean upon light, sandy soils, naturally deficient in moisture.

The medium green soy bean, on the other hand, prefers a medium moist loam, and will yield more dry food material, and especially more seed to the acre at moderate temperatures, than the cow pea. The cow pea is better suited to southern, and the soy bean to northern conditions, and the latter is regarded as decidedly preferable in New England.

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[1] This division is giving what is termed the "protein problem" considerable attention. While the growing of soy beans, cow peas and clover will in many cases prove economical, it is believed that the majority of Massachusetts dairymen will be obliged to purchase at least a portion of their protein in the form of cotton-seed meal, gluten or other nitrogenous meals, and depend upon the farm for the production of the carbohydrates in the form of hay and corn.

D. The Pentosans.

J. B. LINDSEY.

(*a*) *Character of Plant Tissue.*

Various investigations have shown that the larger part of the cellular structure of vegetables and coarse fodders consists :[1] (1) of substances insoluble in water, but soluble in dilute mineral acids, and which are classified as hemi-celluloses; (2) of substances insoluble to any extent in dilute mineral acids, alkali, or F. Schulze's reagent, and which are turned blue by sulphuric acid and iodine, namely, the true celluloses; (3) of lignin acids, which compose one-third to one-half of the true woods, but exist only in small quantities, if at all, in the soft new cells of young plants and vegetables.

Under the hemi-celluloses[2] belong the mother substances dextran, lævulan, mannan, galactan and pentosans (araban and xylan), which on inversion yield dextrose, lævulose, mannose, glactose, arabinose and xylose. These hemi-celluloses are intermixed and perhaps chemically united to the true celluloses and ligno-celluloses in the cell walls of plants and seeds. In some cases they have been recognized as reserve material, and are used as food in the sprouting of the seed.

The true celluloses, upon being dissolved in strong sulphuric acid, and the resulting product hydrolyzed with dilute acid, yield dextrose as a rule, hence the name dextroso cellulose. Schulze has also recognized mannose and xylose, consequently there exist dextroso, mannoso and pentoso celluloses.

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[1] This classification does not include amyloid, a substance soluble in water, and yielding various sugars by hydrolysis. See Winterstein, Zeitsch. f. physiol. Chem., 15, 1892; also Agricultural Science, 1893, p. 162.

[2] See various publications of E. Schulze in Zeitsch. f. physiol. Chem.

The lignin acids are probably strongly united to the dextroso cellulose, and it seems reasonable to suppose also to the pentoso cellulose.

(b) *Recognition of the Pentosans.*

By treating wood with dilute alkali, and precipitating the extracted material with alcohol and hydrochloric acid, Th. Thomson[1] obtained a substance termed wood gum (Holzgummi); and by inversion Koch[2] secured wood sugar or xylose, which was carefully examined by Wheeler,[3] Allen[4] and Tollens, and declared to be a pentose ($C^5H^{10}O^5$). The mother substances in wood gum and also in cherry gum[5] contain less water than the pentoses, and are termed pentosans ($C^5H^8O^4$). The substance yielding xylose was termed xylan, and that yielding arabinose, araban.

(c) *Methods for Determination of Pentosans.*

After wood gum and the resulting sugar had been carefully studied, it became necessary to obtain a method for their quantitative determination, in order to note to what extent they occurred, especially in agricultural products. The first experiments were made by Stone, Wheeler, Allen and Tollens,[6] by dissolving the substance in hydrochloric acid, precipitating the furfural with ammonia, and weighing the resulting furfuramid.

Gunther[7] and Tollens distilled with hydrochloric acid of 1.06 specific gravity, and titrated the distillate with acetate of phenylhydrazine, using analine acetate as indicator.

Stone[8] proposed a method in which he titrated the distilled furfural with a dilute solution of phenylhydrazine of known strength, using Fehling solution as indicator.

De Chalmot[9] and Tollens precipitated the furfural distillate

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[1] Journal for Pract. Chem., 19, (2) p. 146.
[2] Pharm. Zeitsch. für Russland, 25, p. 619, 635, 651.
[3] Liebig's Ann. Chem., 254, p. 304.
[4] Liebig's Ann. Chem., 260, pp. 289–306.
[5] From cherry gum, Scheibler first obtained the arabinose ($C^5H^{10}O^5$).
[6] Loco citato.
[7] Berichte, 23, p. 1751; 24, p. 3575.
[8] Journal of Analyt. and Applied Chem., Vol. V, No. 8, p. 421.
[9] Berichte, 24, p. 3579.

with acetate of phenylhydrazine, dried and weighed the precipitate in glass tubes. This method was further studied and improved by Flint,[1] Mann[2] and Tollens, and was designated the phenylhydrazine method. The Association of Official Agricultural Chemists adopted this method at its meeting in 1895, and later it was slightly modified by Krug.[3]

Hotter[4] recommended that, in place of phenylhydrazine, a portion of the furfural distillate be heated in closed glass tubes with pyrogallol, and that from the weight of the resulting precipitate be calculated the percentage of furfural.

Counciler[5] suggested that phloroglucol be employed instead of the pyrogallol, for the reason that the union of the furfural with the phloroglucol would take place at ordinary temperature. Krüger,[6] Rimbach[7] and Tollens studied and perfected the method, and recommended it as reliable for the determination of pentosans in coarse fodders, grains and vegetables. The Association of Official Agricultural Chemists adopted the phloroglucol method as recommended by Krüger and Tollens in 1897, as a provisional method with slight modifications, the most important of which was the use of the Gooch crucible in place of filter paper for collecting the precipitate. Kröber[8] and Tollens have recently published the results of a very exhaustive investigation of the phloroglucol method, together with a complete table for converting any weight of phloroglucid between .030 and .300 gram into furfural, arabinose, araban, xylose, xylan, pentose and pentosans. The principal conclusions were as follows: —

1. That the results are not influenced by the length of time (over fifteen hours) the precipitate stands.

2. That the phloroglucid is best collected in a Gooch crucible.

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[1] Berichte, 25, p. 2912; Landw. Vers. Stat., 42, p. 381.
[2] Zeitsch. f. Angw. Chem. 1896, p. 33, 194.
[3] Bulletin 49, Division of Chemistry, U. S. Department of Agriculture.
[4] Chemiker Zeitung, 1893, p. 1743.
[5] Chemiker Zeitung, 1894, No. 51.
[6] Zeitsch. für Angw. Chem., 1896, Heft 2.
[7] Inaug. Diss. Göttingen, 1898.
[8] Journal f. Landw., 1900, p. 357; 1901, p. 7.

3. That the precipitate should be washed with small quantities of water, and should not be allowed to become dry during the washing.

4. That the presence of diresorcol in the phloroglucol does not affect the results.[1]

5. That the precipitate be dried four hours in a water bath, and that the Gooch crucible be kept in a glass bottle during the drying, and be weighed in the glass-stoppered bottle after cooling, in order to prevent the hydroscopic phloroglucol from taking on water.

The Association of Official Chemists at its 1902 meeting adopted Kröber's formulæ and tables for calculating the results.

While the phloroglucol method has been perfected, it can still be regarded only as a conventional method. Furthermore, the fact must not be overlooked that other substances besides pentosans yield furfural. Thus Tollens[2] and his earlier pupils have shown that glycuronic, euxanthic and urochloralic acids yield furfural on distillation with hydrochloric acid, and Cross and Bevan[3] have obtained furfural from oxycellulose. Widstoe[4] and others[5] have also shown that methyl pentosans $C^5H^7(CH)^3O^4$ frequently accompany the true pentosans, and upon distillation yield methyl furfural $C^5H^3(CH)^3O^2 + 2H^2O$ and is likewise precipitated by phloroglucol. Fraps[6] finds that the hydrochloric acid distillate from hay yields on standing, besides furfural, a black precipitate and other substances which are precipitated by phloroglucol. These latter he termed furaloids.

Cross and Bevan[7] have applied the term furfuroids in place of pentosans to all furfural-yielding substances. Tollens, on the other hand, as well as Stone,[8] believe it preferable to retain the old name.

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[1] This statement has been disputed by American chemists (see especially Fraps, Bulletin No. 172, North Carolina Experiment Station).

[2] Loco citato.

[3] Berichte, 27, p. 1061.

[4] Berichte, 33, p. 143.

[5] Zeitsch. für Angw. Chem., 1902, Heft 20, p. 481.

[6] Am. Chem. Jour., 25, p. 501.

[7] Chemical News, 1894; Am. Chem. Jour., 22, p. 634.

[8] Chemical News, 1895, p. 40.

(*d*) *Perfected Methods*[1] *for the Determination of the Pentosans. — Present Phloroglucol Method.*

Reagents.

Twelve per cent. hydrochloric acid (specific gravity 1.06): 275 c.c. conc. acid (specific gravity 1.20) to 725 c.c. water; test with a hydrometer as 15° C.

Phloroglucol solution (purified): 11 grams are dissolved in 300 c.c. hot 12 per cent. acid by constant stirring, made up to 1,500 c.c. with cold acid, allowed to stand several days for the diresorcinol to crystallize out, and filtered immediately before use.

Pumice stone: the stone is prepared by dropping it at white heat into distilled water, and leaving it there until required.

Aniline acetate (test solution): equal parts of aniline and 50 per cent. acetic acid.

Apparatus.

Erlenmeyer flask, 300 c.c.; Liebig condenser and Aubrey connecting tube; separatory funnel (open); graduated cylinders; beaker, 25 ounce; Gooch crucible.

Method.

A weight[2] of material[3] that will not yield over .300 gram of phloroglucid is brought into a 10-ounce Erlenmeyer flask, together with 100 c.c. of 12 per cent. hydrochloric acid and several pieces of pumice stone. The flask, placed on a wire gauze, is connected with a Liebig condenser, and heat applied, gently at first, and regulated so as to distil over 30 c.c. into a graduated cylinder in ten minutes. The 30 c.c.

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[1] The phenylhydrazine method will be found described in the twelfth report of the Massachusetts State Experiment Station, p. 177, and in Bulletin No. 51, Division of Chemistry, U. S. Department of Agriculture. The phloroglucol method, as used in this laboratory for a number of years, is described in Bulletin No. 51, just referred to, and in the ninth report of the Hatch Experiment Station, p. 97.

[2] With material containing pentosans: 30 per cent., take 1 gram of material; 25 per cent., take 1.25 grams of material; 20 per cent., take 1.50 grams of material; 15 per cent., take 2 grams of material; 10 per cent., take 3.25 grams of material; 5 per cent., take 5 grams of material.

[3] Previous extraction with ether is not warranted, except with materials of a high fat content.

driven over are replaced by a like quantity of dilute acid by means of an "open-top" separatory funnel, the flask agitated to wash down the particles adhering to the sides, and the process continued until the distillate amounts to 360 c.c.[1]

The completed distillate is filtered to remove insoluble fats into a 25-ounce lipped beaker, graduated at 500 c.c., and 50 c.c. of phloroglucol solution gradually added, precipitating the furfural as phloroglucid, and the mixture thoroughly stirred. The solution is made up to 500[2] c.c. with 12 per cent. acid, and allowed to stand at least fifteen hours.

The amorphous black precipitate is filtered under pressure into a tared Gooch through an asbestos felt, washed carefully, never allowing it to become dry, with 150 c.c. of water, dried at 100° C. to a constant figure, weighed in a glass-stoppered bottle, and the increase reckoned as phloroglucid, from which furfural, pentosans, etc., can be calculated by the following formulæ: —

1. Less than .300 Gram Phloroglucid.

1. Furfural = (weight of the phloroglucid + .0052) × .5170
2. Pentosans = (weight of the phloroglucid + .0052) × .8935
3. Pentose = (weight of the phloroglucid + .0052) × 1.0156

2. More than .300 Gram Phloroglucid.

1. Furfural = (weight of the phloroglucid + .0052) × .5180
2. Pentosans = (weight of the phloroglucid + .0052) × .8822
3. Pentose = (weight of the phloroglucid + .0052) × 1.0025

Kröber has published very complete tables for calculating the results, which will soon be reproduced by the Association of Official Agricultural Chemists.

(*e*) *Digestibility of the Pentosans.*

The investigations of Günther, De Chalmot, Flint, Mann, Krüger, Glaubitz, Kröber and Tollens, Cross and Bevan,[3]

[1] Theoretically, the process should be continued as long as the distillate gives a reaction with aniline acetate on filter paper, but 12 distillates are usually considered sufficient.

[2] Tollens advises 400 c.c., but in this laboratory 500 c.c are preferred.

[3] Loco citato.

Winterstein,[1] Stift,[2] Stone,[3] Lindsey and Holland,[4] Wittmann[5] and others, have shown the pentosans to be very widely distributed in plants and seeds, and this general distribution naturally leads to an inquiry as to their nutritive value in the animal economy. Several investigations have been published relative to the ability of both men and animals to assimilate the sugars, xylose and arabinose. Ebsten[6] fed 25 grams of these sugars to men, and found this amount in the urine in a short time. Cremer,[7] on the other hand, found only 10 grams of arabinose in the urine after feeding 25 grams to a healthy man. Salskowski[8] concluded that rabbits were able to assimilate a portion of this sugar, and that as a result the per cent. of glycogen in the body is materially increased. Frentzel's[9] investigations indicated that glycogen could not be formed from xylose in the animal organism, that the xylose prevented the destruction of substances that naturally produced glycogen, thus causing an increase in the amount of this animal sugar in the body. Salskowski[10] found that a rabbit and hen excreted only a fifth of the arabinose fed.

Cross, Bevan and Remington[11] digested brewers' grains with 1 per cent. sulphuric acid in an autoclave at 130° C., neutralized, with carbonate of lime, filtered, evaporated the solution, and obtained 39.5 per cent. of furfural in the dry matter. The evaporated product, when mixed with gelatine and bread and fed with vegetables to rabbits, proved to be 94.5 to 98.4 per cent. digestible, no furfural or pentoses being recognized in the urine. The investigators claim that,

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[1] Zürcher Diss., 1892, p. 31.

[2] Osterr. Unger. Zeitsch. für Zücherindustrie, 1894, p. 925.

[3] Agricultural Science, 5, p. 6.

[4] Twelfth Report of Massachusetts Experiment Station, 1894, p. 175; Agricultural Science, 8, p. 162; Proceedings of the sixteenth meeting of the Society for the Promotion of Agricultural Science, 1895.

[5] Zeitsch. Landw. Versuchst. Osterr., 4, pp. 131–139. Abs. Exp. Sta. Rec., 13, p. 420.

[6] Centralblatt f. die medicin. Wissenschaften, 1892, p. 577.

[7] Zeitsch. f. Biologie, 24, p. 484.

[8] Centralblatt f. die medicin. Wissenschaften, 1893, p. 193.

[9] Archw. f. d. ges. Physiologie, 56, p. 273.

[10] Zeitsch. Physio. Chem., 1895, p. 491.

[11] Journal of the Am. Chem., Sec. 22, p. 633.

when fully hydrolized, these substances are as digestible as starch and its hydrolized product; and in this respect they differ from the pentoses and their anhydrides. J. König and F. Reinhardt[1] report experiments with a man in which canned peas, dried peas and other foods rich in pentosans were added to a mixed diet. The results indicated that the pentosans were very thoroughly digested and assimilated.

A number of experiments have been made with farm animals, to study the digestibility of the pentosans. In 1892, Stone[2] fed corn meal and wheat bran to rabbits, and found that about 60 per cent. of the pentosans did not reappear in the fæces. A like conclusion was drawn a year later by Stone and Jones[3] from hay and different grasses fed to sheep. Lindsey and Holland[4] fed hay and different grains to sheep, and found from 55 to 90 per cent. of the pentosans digested, traces only being recognized in the urine. Weiske and Wicke reported similar results.[5] Sherman[6] found the pentosans in wheat bran to be 66.2 per cent. digested. Fraps[7] determined the digestibility of pentosans in a number of cattle feeds. The pentosans in the crude fibre he termed pseudo-pentosans, which proved less digestible than what he termed the true pentosans, as found in the nitrogen-free extract.

In addition to the experiments already reported,[8] the writer[9] has made a number of others with different varieties of hays and grains.

The table which follows contains the percentage and digestion coefficient of the pentosans, and, for the sake of comparison, the percentages and digestion coefficients of each of the other groups of substances in the several feed stuffs.

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[1] Zeitsch. Untersuch. Nahr. u. Genussmtl., 1902, No. 3, pp. 111–116.

[2] Am. Chem. Journal, 14, p. 9.

[3] Agricultural Science, 5, p. 6.

[4] Twelfth report of Massachusetts State Experiment Station, p. 175; report of the Society for Promotion of Agricultural Science, 1895, p. 54.

[5] Zeitsch. f. physiol. Chem., 20, p. 489.

[6] Journal of the Am. Chem., Sec. 19, p. 308.

[7] North Carolina Experiment Station, Bulletin No. 172.

[8] Loco citato.

[9] Together with E. B. Holland.

It includes all experiments made at this station to determine the digestibility of the pentosans.

Description of Feed Stuffs.

English Hay. — Largely Kentucky blue-grass, with a sprinkling of timothy, red-top, meadow fescue and sweet vernal grass, together with some clover.

Millet Hay. — *Panicum crus-galli.* The cultivated species of barnyard grass from Japan, now known as barnyard millet.

Black Grass. — *Juncus Gerardi.*

Fox Grass. — *Spartina patens.*

Branch Grass. — *Distichlis spicata.*

Cove Mixture. — A mixture of black grass and red-top.

Salt Mixture. — A mixture of fox grass and branch grass.

Flat Sage. — *Spartina stricta maritima* var. A variety of creek sedge or thatch. It rarely blossoms, and is easily recognized by its pale-green color.

Buffalo Gluten Feed. — The residue in the manufacture of starch from corn. It contains the gluten, bran and some broken germs. This is an old-process meal. In the new process the oil is largely removed.

New and Old Process Linseed Meals. — Crushed flax seed, after the oil has been expressed. The former is treated by the naphtha process, and the latter by warm pressure.

Atlas Meal. — The dried residue in the process of manufacturing alcohol, spirits and whiskey from the several cereals.

Peanut Feed. — Ground peanut husks.

Composition and Digestibility of Feed Stuffs, with Especial Reference to the Pentosans (Per Cent.).

Series.	Feed Stuff.	Composition (Dry Matter).						Digestibility.					
		Ash.	Protein.	Fibre.	Extract Matter.	Fat.	Pentosans.	Ash.	Protein.	Fibre.	Extract Matter.	Fat.	Pentosans.
00,	English hay (a),	6.58	11.10	30.33	48.51	3.48	19.80[1]	-	63.49	64.46	63.32	51.43	63.25
0,	English hay (a),	7.09	11.17	32.09	46.42	3.23	20.84[1]	-	59.77	63.69	60.60	51.49	64.79
III.,	English hay (a),	5.53	9.49	32.23	49.53	3.22	22.15	-	58.48	58.64	60.73	50.78	-
00,	English hay (b),	7.83	10.79	32.74	45.56	3.08	21.87[1]	-	57.32	57.14	57.85	46.90	62.54
IV.,	English hay (b),	6.34	10.04	32.67	48.53	2.42	22.25	46.25	61.22	64.96	63.17	49.51	63.95
0,	English hay (d),	7.63	9.74	32.96	47.26	2.41	20.78[1]	-	58.10	57.29	56.69	46.82	57.36
I.,	Meadow or swale hay,	6.20	7.97	31.06	52.90	1.87	18.25	-	33.88	32.97	46.03	43.60	28.62
IV.,	Barnyard millet hay,	10.18	10.73	34.48	43.05	1.56	23.35	63.15	63.67	61.59	51.58	46.34	60.66
III.,	Black grass,	7.87	8.71	28.71	52.23	2.48	24.95	68 97	54 29	57.35	49.04	45.71	47.69
I.,	Black grass,	11.67	9.51	26.80	49.54	2.48	25.22	-	62.88	60.50	56.34	41.45	63.13
I.,	Fox grass,	8.14	7.48	26.41	55.46	2.51	25.75	-	62.70	50.37	53.26	46.64	45.40
I.,	Fox grass,	5.84	7.13	26.57	57.89	2.57	28.20	-	57.00	51.30	52.00	23.80	48.98
III.,	Fox grass,	7.51	8.76	26.96	54.31	2.46	26.37	58.24	59.30	57.40	53.12	36.39	50.31
I.,	Branch grass,	10.29	8.27	26.47	52.76	2.21	26.42	-	62.26	52.25	53.78	31.48	53.50
III.,	Branch grass,	7.85	7.87	26.46	55.00	2.82	26.15	58.13	51.69	56.41	45.74	36.65	44.81
III.,	Cove mixture,	7.19	8.82	27.57	54.32	2.10	22.24	57.50	47.92	59.68	53.19	40.33	53.18
III.,	Salt mixture,	9.98	6.48	26.77	54.26	2.51	24.09	68.77	41.72	57.51	52.28	27.90	48.52

IV.,	Flat sage,	9.79	7.82	29.71	49.77	2.91	23.82	61.96	51.77	60.42	55.05	36.14	58.05
00,	Buffalo gluten feed,	.78	26.35	8.38	50.20	14.29	16.64[1]	-	84.95	43.10	81.40	81.41	79.32
0,	Buffalo gluten feed,	.40	22.93	8.46	54.89	13.32	17.22[1]	-	87.13	88.94	86 92	93.17	85.08
00,	New-process linseed meal,	5.84	40.40	8.59	41.56	4 01	13.21[1]	-	87.24	61.23	85.51	91.01	88.34
00,	Old-process linseed meal,	6.97	36.75	8.21	39.80	8.27	13.24[1]	-	88.79	57.02	77.55	88.59	83.99
00,	Corn cobs,	1.92	3.86	27.17	65.77	1.28	30.35[1]	-	17.38	65.33	60.04	50.11	63.12
00,	Dried brewers' grains,	3.59	22.99	14.52	51.09	7.81	23.77[1]	-	79.26	52.57	57.83	91.11	56.48
00,	Spring wheat bran,	6.13	17.60	11.48	59.39	5.40	28.22[1]	-	79.63	23.59	70.38	75.60	62.41
00,	Winter wheat bran,	6.24	17.04	9.32	62.83	4.57	23.95[1]	-	78.54	56.28	70.43	60.54	64.24
0,	Atlas meal,	1.03	42.63	9.73	30.84	15.77	12.76[1]	-	72.80	105.70	84.45	91.24	90.03
0,	Peanut feed,	5.06	12 06	54.40	22.94	5.54	20.69[1]	-	70.56	11.68	49.05	89.68	40.51
0,	Soy bean meal,	6.20	38.47	4.50	31.94	18.89	5.18[1]	-	90.05	50.42	72.17	85.02	64.43

[1] These results were obtained by the phenylhydrazine method; the others, by the Krüger and Tollens phloroglucol method.

The results show that the pentosans comprise from one-tenth to nearly one-third of the entire feed stuff, the grains and by-products naturally containing the smaller and the coarse feeds the larger amounts.

The pentosans are found to be fully as digestible as the other fodder groups in case of upland hays and most by-products, but rather less digestible in swale hay, salt grasses and wheat bran. An explanation of this is to be found in the fact that association affects the digestibility of the pentosans. Late-cut hays, straws and bran contain considerable lignified matter, and it is this lignified or incrusting substance which exerts a negative influence upon the digestibility of all of the several fodder groups, the pentosans proving no exception. Most grains contain relatively small amounts of lignin and pentosans. Concentrated by-products, the residues of the several grains from which the starch, fat or both have been removed, contain higher pentosans percentages than the grains, for the reason that the pentosans are found largely in the external coverings, which are always more or less lignified. The pentosans, being closely associated with the lignified tissue, are in such cases less digestible than the protein, fat or total extract matter. In other cases (gluten feed), the incrusting substances being less developed, the pentosans have a digestibility nearly equal to the other groups.

Lehmann,[1] and later Kellner and Köhler,[2] have clearly shown that lignin interferes with the digestibility of the pentosans. The former subjected oat and wheat straws to the action of dilute sodium hydrate, under low pressure, for several hours, neutralizing with hydrochloric acid. After this treatment the pentosans in oat straw showed an increased digestibility of 69 per cent. and those in wheat straws of 115. Kellner, by a similar process, found the fibre and pentosans in extracted rye straw to be respectively 84.5 and 84.8 per cent. digested.

The experiments herein reported show that sheep were able to digest from 40 to 90 per cent. of the pentosans in grains and by-products. It has been held, however, that,

[1] Landw. Jahrbücher 24. Jahrg., 1895; I Erganzungsband, p. 118.
[2] Landw. Versuchsstationen 53, p. 278.

although these quantities are removed from the digestive tract, it is by no means certain that they have a food value equal to starch and similar substances. Considerable quantities have been recognized in the urine of human beings. Weiske and Wicke,[1] as well as ourselves, have recognized only traces in the urine of sheep. It has been assumed that they may be destroyed in the digestive tract by various micro-organisms. Tollens[2] very pertinently suggested that they were no less susceptible to such destructive influences than is starch.

It remained, however, for Kellner,[3] as a result of very exhaustive experiments with the aid of the respiration calorimeter, to furnish definite information. Oxen were fed a basal ration, to which were added at different times 2.5 kilograms of starch and 3 kilograms of rye straw, the latter previously extracted with dilute sodium hydrate under pressure. He found 2.32 per cent. of the carbon from the digested starch to be in the form of marsh gas (equivalent to a loss of 10.1 per cent. potential energy); and, from the extracted straw[4] digested, 3.34 per cent. of the carbon to be in the form of marsh gas (equal to a loss of 14 per cent. of potential energy). The differences were not marked. In general, the poorer the mechanical condition of the feed and the larger the amount of incrusting substance present, the longer it remains in the intestines and the greater the opportunity for micro-organisms to attack it; and, *vice versa*, the more easily digested starchy matters, free from lignin, are more quickly resorbed and are less likely to undergo bacterial destruction. Kellner concluded that the furfural-yielding substances (pentosans) of the extracted straw took part in the formation of fat, and indirectly in the formation of flesh, to as great an extent as did either starch or cellulose.[5]

It may be safely concluded, therefore, that the pentosans are as digestible as any of the other fodder groups (except in the presence of excessive incrusting substance), and that the digested material is practically utilized in the animal organism to the same degree as the other carbohydrates.

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[1] Loco citato. [2] Journal f. Landw., 1897, p. 110. [3] Loco citato, pp. 426–428.

[4] This treated straw contained 82 per cent. of crude fibre, and over 30 per cent. of pentosans. [5] Loco citato, p. 457.

E. Digestion Experiments with Sheep.

J. B. LINDSEY.[1]

Digestion experiments were begun with sheep at this station in 1893. Two series were published in full in the eleventh and twelfth reports of the Massachusetts State Experiment Station, together with a description of the method employed (see eleventh report). Since 1894 the coefficients only of several series have been published in different reports of the Hatch Experiment Station. In the table which follows will be found the results of 185 single trials with 73 feed stuffs, being the entire number of experiments made between 1894 and 1902, excepting a few which gave results of uncertain value, and hence were discarded. The complete data for each experiment is on file at this station.

It is believed that the brief description of the various feeds found in the table will suffice in most instances to give a clear understanding as to their character. The following additional information may prove of value: —

Mixed grasses in the table includes Kentucky blue-grass, red-top, timothy, meadow fescue, sweet vernal grass, and alsike and red clover. Kentucky blue-grass and clover predominated.

English hay is a term commonly used in many localities for good upland hay, as distinct from salt and swale hays.

Gluten meal consists of the glutinous part of the corn, mixed with the starchy portion, that cannot be recovered by mechanical methods.

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[1] These experiments were made with the co-operation of a number of assistants. The results in the following table were compiled from the completed data by P. H. Smith.

Gluten feed includes the glutinous part of the corn (gluten meal), together with the corn bran and broken germs.

Germ oil meal consists of the ground corn germs, from which the oil has been partially pressed.

Distillers' grains are the dried residues in the process of manufacturing alcohol, spirits and whiskey from the several cereals.

H-O feeds consist of oat offals and light oats as a basis, together with some corn, and fortified with wheat bran and cotton-seed or gluten meal.

Quaker dairy feed — formerly Quaker oat feed — consists principally of oat offal, fortified with some material rich in protein.

Data of Digestion Experiments with Sheep, 1894–1902.

[The teachings from these experiments are presented from time to time in popular bulletins treating of feeds and feeding. — J. B. L.]

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance. Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).	Sheep Number.	Digestion Coefficients. Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I.,	English hay, "D," mixed grasses in bloom (taken from twelfth annual report, State Experiment Station).	-	7.63	9.74	32.97	47.25	2.41	-	55.00	-	58.00	57.00	57.00	47.00
II.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	7.15	5.83	7.47	36.41	47.90	2.39	1	54.90	-	53.52	56.34	55.73	41.54
								2	55.68	-	47.02	59.68	56.26	38.67
								3	57.83	-	56.25	59.60	58.85	44.42
								4	58.19	-	54.77	60.72	58.73	46.12
								Av.,	56.65	-	52.89	59.09	57.39	42.69
II.,	English hay, "B," mostly *poa pratensis* in bloom, 850 gm.	8.22	5.94	11.07	32.00	47.92	3.07	2	62.37	-	62.17	64.28	62.72	56.18
								4	65.30	-	62.86	69.76	65.38	51.27
								Av.,	63.84	-	62.52	67.02	64.05	53.72
III.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.,	7.41	5.53	9.49	32.23	49.53	3.22	1	60.33	45.63	56.33	63.09	61.31	54.79
								2	58.43	49.45	59.78	57.11	60.52	50.57
								3	56.36	44.73	52.58	56.26	59.21	44.44
								4	59.26	46.34	57.18	60.17	60.95	50.99
								Av.,	58.60	46.54	56.47	59.16	60.50	50.20

III.,	English hay, "B," the same as III., "A," . . .	-	-	-	-	-	-	1	59.60	52.19	57.53	60.68	60.20	53.85
								5	63.18	48.45	62.47	65.90	63.54	57.63
								6	59.95	49.50	59.46	59.28	61.86	56.24
								Av.,	60.91	50.05	59.82	61.95	61.87	55.91
IV.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	11.54	6.34	10.04	32.67	48.53	2.42	1	61.52	43.80	59.48	66.00	61.90	48.11
								2	59.55	45.13	59.83	61.05	60.96	47.40
								3	62.61	47.94	63.09	64.77	63.69	48.27
								4	63.40	47.35	61.50	66.56	64.37	51.31
								5	63.13	45.92	61.69	66.05	64.36	50.03
								6	62.68	47.36	61.74	65.32	63.71	50.34
								Av.,	62.15	46.25	61.22	64.96	63.17	49.51
V.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	13.36	6.84	9.32	34.52	47.02	2.30	1	57.16	47.96	60.01	53.47	61.30	43.64
								2	60.15	47.95	62.22	59.00	62.85	48.51
								3	56.30	43.80	57.56	54.87	59.66	40.94
								4	57.33	52.59	61.39	53.69	60.22	49.33
								5	60.26	47.78	60.79	60.20	62.56	49.31
								6	60.11	49.45	62.16	59.60	62.08	50.94
								Av.,	58.63	48.26	60.76	56.81	61.45	47.11

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
VI.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	14.46	6.01	10.49	33.43	47.10	2.97	1	63.30	48.78	65.16	62.75	65.54	56.75
								2	61.73	48.87	64.87	58.79	65.11	56.17
								3	63.85	47.73	64.57	63.67	66.29	58.01
								4	63.28	48.25	65.45	64.58	64.19	56.88
								5	62.47	47.23	64.69	63.67	63.22	60.04
								Av.,	62.93	48.11	64.95	62.69	64.87	57.57
VII.,	English hay, "A," the same as VI., "A," sampled a year later.	10.13	4.44	9.78	32.71	50.45	2.62	-	63.00	48.00	65.00	63.00	65.00	57.50
II.,	Timothy hay, 850 gm., ...	7.60	6.16	9.64	33.98	47.22	3.00	1	55.09	-	57.15	55.52	54.72	56.76
								2	55.87	-	50.65	59.16	55.85	58.24
								Av.,	55.48	-	53.91	57.34	55.29	57.50
IV.,	English hay, mixed grasses, late cut, 900 gm., . .	11.94	5.64	9.39	34.73	48.32	1.92	2	52.39	22.39	51.18	55.26	54.44	36.53
								3	53.54	29.57	56.66	56.71	53.97	40.73
								Av.,	52.96	25.98	53.92	55.98	54.20	38.63

IV.,	English hay, mixed grasses, late cut, 900 gm.,	9.95	5.40	9.57	33.98	48.98	2.07	1	56.92	38.53	54.29	61.17	56.89	46.73
								2	56.57	45.65	56.27	57.07	58.08	42.10
								Av.,	56.74	42.09	55.28	59.12	57.49	44.42
I.,	Black grass, *Juncus Gerardi* (fed with 450 gm. English hay, I., "D"), 450 gm.	22.66	11.67	9.51	26.80	49.54	2.48	3	56.69	-	62.47	56.80	53.40	37.31
								4	62.35	-	63.29	64.20	59.29	45.77
								Av.,	59.52	-	62.88	60.50	56.34	41.45
III.,	Black grass, *Juncus Gerardi*, rather damp and mouldy (fed with 400 gm. English hay, III., "A"), 500 gm.	16.44	7.87	8.71	28.71	52.23	2.48	2	50.06	70.95	52.62	50.43	46.64	41.40
								3	51.37	66.96	52.57	56.06	46.44	44.39
								4	58.82	69.00	57.68	65.55	54.04	51.35
								Av.,	53.42	68.97	54.29	57.35	49.04	45.71
I.,	Branch grass, *Distichlis spicata* (fed with 400 gm. English hay, I., "D"), 600 gm.	18.13	10.29	8.27	26.47	52.76	2.21	3	56.68	-	63.19	56.06	55.20	35.57
								4	54.52	-	61.34	48.45	52.37	27.39
								Av.,	55.60	-	62.26	52.25	53.78	31.48
III.,	Branch grass, *Distichlis spicata*, in poor condition (fed with 400 gm. English hay, III., "A"), 500 gm.	22.98	7.85	7.87	26.46	55.00	2.82	2	49.43	58.19	52.16	56.63	45.25	34.53
								3	50.08	60.30	50.97	56.33	46.54	33.24
								4	49.54	55.90	51.93	56.27	45.42	42.17
								Av.,	49.68	58.13	51.69	56.41	45.74	36.65
I.,	Fox grass, *Spartina patens* (fed with 450 gm. English hay, I., "D"), 450 gm.	14.30	8.14	7.48	26.41	55.46	2.51	3	50.63	-	62.83	45.55	51.85	42.25
								4	54.82	-	62.48	55.19	54.68	51.03
								Av.,	52.70	-	62.70	50.37	53.26	46.64

Data of Digestion Experiments with Sheep, 1894-1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I.,	Fox grass, *Spartina patens* (fed with 400 gm. English hay, I., "D"), 550 gm.	15.37	5.84	7.13	26.57	57.89	2.57	3	51.54	-	56.99	49.25	52.30	17.30
								4	54.11	-	57.41	53.39	51.20	30.26
								Av.,	52.80	-	57.00	51.30	51.50	23.80
III.,	Fox grass, *Spartina patens* (fed with 400 gm. English hay, III., "A"), 500 gm.	17.56	7.51	8.76	26.96	54.31	2.46	1	55.82	58.11	55.69	58.67	54.65	41.91
								2	52.94	59.31	61.19	53.64	51.28	31.26
								4	55.74	57.30	61.03	59.89	53.43	36.00
								Av.,	54.83	58.24	59.30	57.40	53.12	36.39
	Fox grass, *Spartina patens*, ...	-	-	-	-	-	-	-[1]	53.44	58.24	59.67	53.02	52.63	35.61
III.,	Salt hay, "cove mixture," black grass and red top (fed with 400 gm. English hay, III., "A"), 500 gm.	18.00	7.19	8.82	27.57	54.32	2.10	2	54.40	58.77	52.04	59.53	52.49	31.20
								3	52.57	57.17	46.49	56.92	51.16	48.03
								4	56.61	56.56	45.22	62.59	55.91	41.75
								Av.,	54.59	57.50	47.92	59.68	53.19	40.33

III.,	Salt hay mixture, fox and branch grasses, etc. (fed with 400 gm. English hay, III., "A") 500 gm.	16.00	9.98	6.48	26.77	54.26	2.51	2	52.18	67.83	42.32	53.91	50.57	30.18
								4	55.97	69.71	41.12	61.11	53.99	25.70
								Av.,	54.07	68.77	41.72	57.51	52.28	27.90
III.,	Red top hay, *Agrostis vulgaris*, bordering salt marsh, mixed with some sedge, over ripe (fed with 400 gm. English hay, III., "A"), 500 gm.	13.00	6.46	7.80	32.38	51.54	1.82	2	45.74	14.57	36.61	54.54	45.06	55.81
								3	45.94	9.19	36.75	54.62	46.37	47.13
								4	46.47	6.46	38.29	58.16	45.39	44.03
								Av.,	46.05	10.07	37.22	55.71	45.61	48.99
IV.,	Flat sage hay, *Spartina stricta maritima* var. (fed with 400 gm. English hay, IV., "A"), 500 gm.	17.00	9.79	7.82	29.71	49.77	2.91	2	55.39	61.41	50.70	59.75	53.67	32.67
								3	57.62	62.32	49.75	61.36	56.74	39.70
								4	56.55	62.15	54.86	60.16	54.75	36.06
								Av.,	56.52	61.96	51.77	60.42	55.05	36.14
I.,	Swale hay, fresh water grasses, sedges, brakes and wild flowers, 1,000 gm.	12.33	6.20	7.97	31.06	52.90	1.87	3	37.88	-	31.11	30.27	46.03	43.60
								4	39.89	-	36.66	35.66	45.99	43.61
								Av.,	38.88	-	33.88	32.97	46.01	43.60
V.,	Meadow fescue hay, *Festuca elatior pratensis*, early blossom, 900 gm.	12.73	6.60	7.33	37.89	45.96	2.22	2	60.29	46.49	53.29	66.79	58.49	53.05
								6	61.29	46.37	51.35	67.34	60.05	54.47
								Av.,	60.79	46.43	52.32	67.07	59.27	53.76

[1] Average of 7 sheep.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter. (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V.,	Tall oat grass hay, *Arrhenatherum elatius*, early blossom, 800 gm.	13.23	5.78	6.51	36.32	49.30	2.09	1	54.01	38.87	51.31	53.04	56.39	57.96
								6	56.56	43.40	50.53	56.67	59.00	53.62
								Av.,	55.27	41.14	50.92	54.86	57.69	55.79
VI.,	Tall oat grass hay, *Arrhenatherum elatius*, late blossom, 900 gm.	10.25	5.34	6.53	40.57	46.16	1.40	4	46.47	13.80	33.27	55.38	44.63	33.16
								5	50.02	25.15	38.08	59.58	46.54	37.29
								Av.,	48.25	19.48	35.69	57.48	45.59	35.23
VI.,	Canada blue grass hay, *Poa compressa*, in blossom, 900 gm.	10.75	5.65	6.86	36.40	48.87	2.22	1	61.97	40.91	42.96	69.94	62.22	38.13
								2	62.51	42.01	43.27	70.69	62.70	35.78
								Av.,	62.24	41.46	43.12	70.32	62.46	36.96
V.,	Kentucky blue grass hay, *Poa pratensis*, in blossom, 900 gm.	10.50	5.75	9.29	37.62	45.59	1.75	2	56.37	42.40	56.67	63.14	53.03	42.52
IV.,	Millet hay, *Panicum Italicum*, 800 gm., ...	12.52	6.34	4.66	35.98	51.38	1.64	3	51.81	15.73	32.08	60.17	52.42	47.72
								4	58.08	31.54	30.06	66.24	58.57	52.31
								Av.,	56.47	23.64	31.07	63.21	55.50	50.02

III.,	Barnyard millet, *Panicum crus-galli*, late blossom, fed green, 3,000 gm.	81.83	8.59	11.00	35.03	43.65	1.73	4	67.17	61.23	72.30	70.64	64.51	61.08
IV.,	Barnyard millet hay, late blossom, the same lot as preceding sample, (fed with 400 gm. English hay, IV., "A"), 500 gm.	12.67	10.18	10.73	34.48	43.05	1.56	1	57.10	62.99	63.69	59.82	52.26	44.18
								5	58.43	62.58	62.92	63.60	52.41	49.62
								6	56.88	63.89	64.39	61.36	50.07	45.21
								Av.,	57.50	63.15	63.67	61.59	51.58	46.34
VI.,	Barnyard millet, just heading out, fed green, 3,000 gm.,	83.36	8.77	10.18	33.60	45.48	1.97	1	67.08	50.94	61.22	71.57	68.71	54.83
								2	70.49	47.83	61.65	77.12	72.61	54.73
								3	67.44	45.09	58.11	73.18	70.19	53.91
								Av.,	68.34	47.95	60.33	73.96	70.50	54.49
VII.,	Barnyard millet hay, just heading out, the same lot as preceding sample, 900 gm.	12.33	9.04	10.24	36.38	42.88	1.46	1	58.75	50.58	56.37	66.42	54.84	49.39
								2	62.39	52.07	59.27	70.84	58.64	47.48
								Av.,	60.57	51.33	57.82	68.63	56.74	48.44
III.,	Barnyard millet, early blossom, fed green, 3,000 gm., .	81.12	7.84	8.44	32.06	49.92	1.74	2	71.51	64.79	66.59	70.94	74.10	61.39
								3	75.51	67.49	69.65	76.79	77.39	67.39
								Av.,	73.51	66.14	68.12	73.86	75.74	64.39
VI.,	Winter wheat and hairy or sand vetch hay (1½—1), 900 gm.	13.72	6.05	12.67	34.20	44.83	2.25	1	64.64	37.36	70.87	64.48	66.85	61.65
								2	64.18	35.70	71.89	63.09	66.71	63.07
								3	64.81	32.53	69.56	66.19	66.69	66.52
								Av.,	64.50	35.20	70.77	64.59	66.75	63.75

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
VI.,	Winter wheat and hairy or sand vetch (1—1) vetch predominating, in blossom, fed green, 3,000 gm.	83.52	9.04	19.58	30.88	37.59	2.91	1	68.51	46.46	77.21	66.85	71.59	56.37
								2	65.71	36.81	73.89	65.51	69.44	54.41
								3	68.40	44.15	77.71	65.80	72.37	57.47
								Av.,	67.54	42.47	76.27	66.05	71.13	55.65
VII.,	Winter wheat and hairy or sand vetch hay, the same lot as preceding sample, 900 gm.	11.90	9.05	19.38	32.21	36.91	2.45	1	67.90	59.63	76.04	64.21	69.24	61.61
								2	69.20	60.42	77.43	65.25	70.74	65.21
								3	67.89	58.19	77.12	63.94	69.15	63.56
								Av.,	68.33	59.41	76.86	64.47	69.71	63.46
VII.,	Winter wheat and hairy or sand vetch (1½—1), fed green (with 300 gm. English hay, VII., "A"), 2,000 gm.	79.57	8.63	15.38	29.34	43.73	2.92	3	68.78	42.23	68.86	69.72	73.71	54.48
								4	71.47	44.95	72.98	71.28	76.38	61.36
								Av.,	70.13	43.59	70.92	70.50	75.05	57.92
VI.,	Canada field peas, full blossom, fed green (with 300 gm. English hay, VI., "A"), 2,000 gm.	83.17	8.83	19.72	31.60	37.20	2.65	1	63.49	43.81	80.40	45.76	75.15	48.10
								2	64.88	40.24	79.26	52.44	74.31	53.36
								3	60.15	44.79	79.14	40.12	71.63	44.95
								Av.,	62.84	42.95	79.60	46.11	73.70	48.80

VII.,	Canada field peas, full blossom, fed green, 3,000 gm., .	86.19	8.81	21.31	28.09	38.48	3.31	1	63.59	32.63	81 49	44.58	75.08	58.42
								2	67.18	33.40	83.49	48.48	79.80	64.11
								3	61.14	26.38	79.75	39.69	74.83	56.89
								Av.,	63.97	30.80	81.58	44.25	76.57	·59.81
VII.,	Hairy or sand vetch in blossom, fed green (with 300 gm. English hay, VI., "A"), 2,000 gm.	82.37	12.82	25.52	26.21	32.12	3.33	1	68.99	30.33	82.12	61.19	79.87	64.48
								2	72.51	28.65	81.40	70.37	84.13	68.99
								Av.,	70.75	29.49	81.76	65.78	82.00	66.74
III.,	Spring vetch and oats (1—1) in blossom, fed green, 3,000 gm.	83.10	8.70	12.78	35.48	40.34	2.70	2	67.17	54.81	75.96	67.85	67.76	47.63
								3	69.26	53.71	75.00	71.53	69.97	52.09
								4	64.70	49.45	73.33	65.47	65.98	41.93
								Av.,	67.04	52.66	74.76	68.28	67.90	47.22
III.,	Canada peas and oats (1—1), in blossom, fed green, 3,000 gm.	82.80	7.99	11.24	31.05	46.67	3.05	2	69.63	51.62	69.43	66.50	75.56	58.59
								3	72.01	51.20	73.21	70.32	77.12	61.19
								4	69.03	45.26	67.72	68.07	75.21	51.46
								Av.,	70.22	49.36	70.12	68.29	75.96	57.08
IV.,	Corn silage, Pride of the North corn, mature (fed with 400 gm. English hay, IV., "A"), 1,500 gm.	72.00	4.62	6.67	20.77	65.13	2.81	1	72.07	24.04	13.40[1]	73.44	80.90	72.05
								5	75.62	27.78	45.34	72.44	82.78	81.78
								Av.,	73.84	25.91	45.34	72.94	81.84	76.91

[1] Omitted from average.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
II.,	Barnyard millet and medium green soy bean silage (fed with 400 gm. English hay, II., "A"), Sheep 1-2, 1,600 gm., Sheep 3-4, 1,800 gm.	81.67	10.55	12.01	36.07	37.12	4.25	1	54.40	-	58.13	57.47[1]	51.49[1]	75.93
								2	58.11	-	52.20	64.32	55.78	72.04
								3	57.95	-	41.79[1]	70.11	58.66	68.59
								4	64.75	-	61.94	73.89	63.29	80.00[1]
								Av.,	58.80	-	57.42	69.44	59.24	72.19
II.,	Corn and soy bean silage (2—1), Pride of the North corn and medium green soy bean (fed with 400 gm. English hay, II., "B"), 1,600 gm.	74.83	7.18	9.42	28.22	52.78	2.40	1	66.42	-	64.84	58.95	72.71	82.83
								2	68.62	-	63.07	64.74	74.31	79.81
								4	71.84	-	67.21	70.63	77.79	83.74
								Av.,	68.96	-	65.04	64.77	74.94	82.13
II.,	Cotton-seed feed, 4 parts hulls, 1 part meal, 850 gm.,	11.88	3.15	11.67	42.45	38.92	3.81	3	56.55	-	36.37	60.37	57.29	85.52
								4	57.57	-	41.86	57.33	59.75	92.65
								Av.,	57.06	-	39.12	58.85	58.52	89.09

III.,	Cotton-seed feed, 4 parts hulls, 1 part meal, 900 gm., .	11.79	3.73	12.21	37.83	42.16	4.07	1	54.74	34.68	42.17	50.89	59.84	93.78
								4	54.03	30.22	44.51	52.16	56.82	92.89
								Av.,	54.38	32.45	43.34	51.52	58.33	93.33
III.,	Cotton-seed feed, 4 parts hulls, 1 part meal (fed with 400 gm. English hay, III., "A"), the same lot as preceding sample, 500 gm.	12.24	-	-	-	-	-	2	57.74	23.52	41.23	59.99	59.84	98.38
								3	57.12	22.54	40.03	57.52	60.43	-
								Av.,	57.52	23.03	40.63	58.76	60.14	98.38
	Cotton-seed feed, average of six preceding tests, . .	-	-	-	-	-	-	-	56.29	27.74	41.03	56.38	58.99	92.64
V.,	Cleveland flax meal (fed with 700 gm. English hay, V., "A"), 150 gm.	10.46	5.82	40.37	9.88	41.32	2.61	1	85.21	23.28	84.05	-	93.98	53.25
								6	88.24	19.05	82.36	-	-	97.15
								Av.,	86.73	21.17	83.21	-	93.98	75.90
II.,	Pope cream gluten meal (fed with 700 gm. English hay, II., "A"), 150 gm.	8.20	.75	39.06	1.71	50.03	8.45	3	91.61	-	83.50	-	90.97	99.14
								4	94.89	-	84.00	-	95.35	-
								Av.,	93.25	-	83.75	-	93.16	99.14
II.,	Pope white gluten feed (fed with 600 gm. English hay, II., "A"), 250 gm.	9.24	1.36	27.92	6.72	55.79	8.21	3	85.90	-	84.52	75.61	90.36	82.02
								4	87.18	-	88.46	78.30	89.97	79.12
								Av.,	86.54	-	86.49	76.95	90.16	80.57
II.,	Buffalo gluten feed (fed with 600 gm. English hay, II., "A"), 250 gm.	8.42	.90	25.10	7.61	52.75	13.64	3	66.51	-	72.73	6.42	71.67	83.03
								4	69.25	-	74.80	11.65	72.56	85.62
								Av.,[2]	67.88	-	73.76	9.03	73.46	84.32

[1] Omitted from average.

[2] Digestibility apparently much too low.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance. Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).	Sheep Number.	Digestion Coefficients. Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III.,	Peoria gluten feed (fed with 600 gm. English hay, III., "B"), 200 gm.	8.53	1.02	22.72	7.15	63.03	6.08	1	93.61	-	84.59	99.77	97.81	89.00
								5	92.76	-	86.39	-	95.71	88.01
								6	87.64	-	82.79	84.94	92.93	83.77
								Av.,	91.34	-	84.59	92.35	95.48	87.59
VI.,	Germ oil meal (fed with 700 gm. English hay, V., "A"), 250 gm.	8.69	3.50	24.72	10.53	49.07	12.18	2	77.05	-	65.33	94.90	89.73	97.66
								3	82.59	-	72.89	-	83.58	95.46
								Av.,	79.82	-	69.11	94.90	86.66	96.66
V.,	Biles distiller's grain, brand R (fed with 600 gm. English hay, V., "A"), 250 gm.	8.80	2.18	17.93	13.69	60.11	6.09	5	55.61	-	56.29	-	61.09	80.06
								6	58.57	-	62.57	-	73.46	88.46
								Av.,	57.59	-	59.43	–[1]	67.28	84.26
V.,	Biles distiller's grain, brand X. (fed with 650 gm. English hay, V., "A"), 200 gm.	8.91	1.84	32.00	10.52	43.95	11.69	1	86.50	-	65.51	-	93.12	93.94
								3	87.07	-	80.05	-	85.15	97.60
								Av.,	86.78	-	72.78	–[1]	89.14	95.77

V.,	Biles distiller's grain, brand XX. (fed with 600 gm. English hay, V., "A"), 250 gm.	9.53	2.70	28.17	12.40	46.21	10.52	1	88.53	-	79.94	-	88.22	94.45
								6	79.77	-	76.50	-	79.77	94.87
								Av.,	84.15	-	77.22	-[1]	84.00	94.66
V.,	Biles distiller's grain, brand XXX. (fed with 600 gm. English hay, V., "A"), 250 gm.	7.46	2.22	32.27	11.11	41.62	12.78	2	79.88	-	73.41	-	78.03	91.78
								6	71.41	-	74.01	-	72.69	93.95
								Av.,	75.65	-	73.71	-[1]	75.36	92.87
V.,	Biles distiller's grain, brand XXXX. (fed with 600 gm. English hay, V., "A"), 250 gm.	8.83	1.86	38.13	12.50	36.74	10.77	1	79.82	-	72.08	-	81.12	96.99
								6	73.47	-	69.22	-	76.73	98.45
								Av.,	76.65	-	70.65	-[1]	78.93	97.70
IV.,	H-O dairy feed (fed with 650 gm. English hay, IV., "A"), 250 gm.	8.20	4.01	19.62	13.84	57.66	4.87	2	63.70	-	75.99	42.98	67.16	88.10
								3	66.84	-	79.64	38.69	72.61	82.83
								Av.,	65.27	-	77.82	40.84	69.89	85.47
VII.,	H-O dairy feed (fed with 650 gm. English hay, VII., "A"), 250 gm.	8.71	4.09	20.37	14.02	56.37	5.15	1	64.65	-	77.50	16.62	75.19	84.43
								2	64.82	-	67.93	41.75	73.99	83.23
								Av.,	64.74	-	72.72	29.19	74.59	83.83
IV.,	H-O horse feed (fed with 650 gm. English hay, IV., "A"), 250 gm.	9.79	3.42	14.33	10.92	67.16	4.17	2	63.46	-	61.20	8.32	76.17	81.17
								3	70.10	-	74.38	35.16	78.70	84.04
								Av.,[2]	-	-	-	-	-	-

[1] The digestibility of fibre varied so much that coefficients are omitted.

[2] The results taken of Sheep 3 only.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
VII.,	H-O horse feed (fed with 600 gm. English hay, VII., "A"), 300 gm.	11.20	3.57	13.39	10.32	68.53	4.19	2	74.40	–	64.90	52.34	84.88	78.49
								3	74.74	–	61.99	58.97	84.16	77.06
								Av.,	74.57	–	63.45	55.66	84.52	77.78
IV.,	Quaker oat feed (fed with 600 gm. English hay, IV., "A"), 300 gm.	7.41	5.39	11.97	19.02	59.67	3.95	1	63.30	–	82.35	44.05	68.14	91.52
								5	63.51	–	84.18	43.00	69.85	88.15
								6	59.04	–	76.87	40.66	64.27	87.24
								Av.,	61.95	–	81.10	42.57	67.42	88.97
VII.,	Quaker dairy feed (fed with 650 gm. English hay, VII., "A"), 250 gm.	8.62	5.06	15.07	17.27	58.84	3.76	1	64.08	–	69.07	56.45	70.50	75.67
								2	57.99	–	61.72	53.69	71.23	80.09
								Av.,	61.04	–	65.40	55.07	70.87	77.88
IV.,	Victor corn and oat feed (fed with 600 gm. English hay, IV., "A"), 300 gm.	9.56	3.75	10.21	12.42	69.44	4.18	1	73.75	–	65.70	35.90	84.89	84.39
								5	74.01	–	71.40	51.72	81.19	88.36
								6	76.45	–	75.41	57.75	82.76	87.74
								Av.,	74.74	–	70.84	48.46	82.95	86.83

V.,	Rye feed, bran and fine middlings (fed with 650 gm. English hay, V., "A"), 250 gm.	12.88	3.17	13.83	3.67	76.33	3.00	4	78.56	30.68	80.71	-	85.68	79.33
								5	84.91	48.19	82.14	-	89.27	90.81
								6	82.73	24.74	77.98	-	88.68	99.08
								Av.,	82.07	34.54	80.28	-	87.88	89.74
II.,	Rice meal (fed with 600 gm. English hay, II., "A"), 200 gm.	10.39	8.57	13.53	5.62	57.81	14.47	1	71.47	-	61.85	-	89.23	90.66
								2	76.19	-	37.36[1]	-	95.28	91.56
								Av.,	73.83	-	61.85	-	92.25	91.11
V.,	Chop feed, hulls bran and broken germs of maize (fed with 650 gm. English hay, V., "A"), 250 gm.	11.08	.93	12.10	14.06	66.75	6.16	1	71.30	-	64.02	58.83	75.56	86.41
								2	92.29	27.54	76.77	-	92.07	85.46
								3	77.47	-	62.64	70.12	82.96	75.60
								Av.,	80.35	27.54	67.81	64.48	83.53	82.49
III.,	Cerealine feed (fed with 600 gm. English hay, III., "A," and 100 gm. Chicago gluten meal), 150 gm.	12.10	2.53	10.85	5.00	74.03	7.59	1	89.59	-	69.69	-	92.62	77.54
								5	92.24	-	79.41	92.41	96.36	83.23
								6	89.39	-	80.59	72.08	96.88	80.94
								Av.,	90.39	-	80.00	82.24	95.29	80.57
VI.,	Corn bran (fed with 500 gm. English hay, VI., "A"), 400 gm.	16.56	1.52	10.27	14.80	68.60	4.81	4	69.87	-	55.22	64.68	74.06	80.25
								5	71.44	-	55.48	64.64	75.82	85.17
								Av.,	70.66	-	55.35	64.66	74.94	82.71

[1] Omitted from average.

Data of Digestion Experiments with Sheep, 1894–1902 — Concluded.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V.,	Parson's $6 feed, grain hulls and mill sweepings (fed with 600 gm. English hay, V., "A"), 300 gm.	11.22	8.88	11.23	20.10	57.41	2.38	1	56.37	13.88	61.96	49.55	62.54	81.07
								3	55.12	10.49	56.23	44.66	64.88	80.00
								Av.,	55.75	12.19	59.09	47.11	63.71	80.54
V.,	Oat feed, inferior (fed with 600 gm. English hay, V., "A"), 250 gm.	9.89	6.23	5.60	30.27	56.30	1.60	1	29.32	9.75	65.29	24.67	29.16	96.94
								2	38.22	20.72	69.26	37.47	35.81	88.89
								3	34.78	8.12	50.95	34.50	35.24	89.17
								Av.,	34.11	12.86	61.83	32.21	33.40	91.67

Influence of Drying and Curing on Digestibility.

Jordan[1] summarized the results of six experiments made to throw light on this point, and states that in only two cases (clover and corn fodder) was there any decrease in digestibility due to drying. Experiments were made at this station with wheat and vetch and barnyard millet, and the results are found in the above tables. It will be seen that in case of the wheat and sand vetch no important difference was noted as a result of the curing process, while in both experiments drying noticeably decreased the digestibility of barnyard millet. Generally speaking, the mere withdrawal of the water is not supposed to affect digestibility, and this is likely to be especially true with young and tender plants and with the finer grasses. In the case of plants with coarse, tough stems, the reverse is likely to be true. The hardening of the woody stems in the curing process and the less perfect mastication resulting, as well as possible chemical and physiological changes, are all factors which may cause lessened digestibility.

Digestion experiments enable the investigator to form a reasonably correct opinion concerning the nutritive and economic value of the different coarse and concentrated feeds. The results of these experiments are presented from time to time in popular bulletins treating of feed and feeding.

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[1] Bulletin No. 77, U. S. Department of Agriculture: The Digestibility of American Feeding Stuffs.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

The work of the agricultural division of the Experiment Station has followed the general lines of earlier years. It has for its chief object to obtain light on some of the numerous conditions determining productiveness, chiefly as affected by different manures and fertilizers used alone and in a wide variety of combinations. The questions connected with the use of manures and fertilizers are self-evidently of vital importance in our agriculture, which cannot, as in some of the newer States of the Union, depend upon the accumulated fertility of ages. Equally self-evident to every intelligent mind must be the fact that the solution of even the simplest problem connected with the use of manures is a matter of much inherent difficulty, so numerous are the conditions which determine production, — conditions, too, many of which are beyond control. It is clearly perceived that much caution should be exercised in drawing conclusions from the results of experiments; that field results especially should be tested again and again, under varying conditions of soil and season; that such results obtained on plots inevitably varying somewhat in natural fertility should be checked by results obtained on equal quantities of thoroughly mixed soils from the same plots under conditions made as nearly normal as possible: as well as by vegetation experiments in plots, where all the conditions of moisture, — exposure, etc., are most perfectly under control. Our work, therefore along these lines includes three distinct methods of experiment: first, plot experiments in the open field; second, closed plot experiments (plunged cylinders) with mixed soil; and third, vegetation experiments in pots.

In connection with lines of inquiry pertaining to the use of manures and fertilizers and in the other lines of work mentioned below we have cared for 251 plots upon our own grounds and have supervised work upon 20 plots in different parts of the State. In our experiments with mixed soil in enclosed plots (plunged cylinders) we have employed 153 cylinders. In our vegetation experiments we have cared for 278 pots.

Variety tests also have received considerable attention. The test with corn, which has included 31 varieties, will not be reported, as the grain is not yet dry enough to shell. We have had under careful observation some 70 species of grasses and forage crops, in addition to 18 varieties of millets. In connection with the grasses we are endeavoring to gain some light as to the relative value of the different kinds for pastures as well as for mowings by lawn-mowing one-half of each plot. We have obtained some striking results, but these will not be reported until we have carried the test further. The work with poultry has been for the most part along the lines which have engaged our attention in previous years, viz., a study of the best methods of feeding for eggs. In connection with our poultry work we are making comparative trials of various types of incubators and brooders, which are being used in raising the fowls we use in our feeding experiments. We are also making careful records touching the food cost of raising chickens.

In this report we shall discuss briefly the results obtained in a portion only of the plot experiments pertaining to the use of manures and fertilizers, selecting for this purpose the results which are confirmed by the greatest number of years' work, as well as in many cases by the closed plot and pot experiments. We shall report also the results of the variety test with potatoes, and shall make a brief statement touching the results obtained in experiments with poultry. The nature of the subjects of inquiry and the more important features of our results will be made clear by the following statement: —

I. — To determine the relative value of barnyard manure, nitrate of soda, sulfate of ammonia, and dried blood as

sources of nitrogen. The crop of this year, potatoes, gives yields on the basis of which the materials rank in the following order: dried blood, sulfate of ammonia, barnyard manure, nitrate of soda. The yield on the last two is, however, below the yield on the plots receiving no nitrogen, and the results are complicated by the fact that the crop suffered from blight and rot. The average to date ranks the materials in the following order: nitrate of soda, barnyard manure, sulfate of ammonia, and dried blood.

II. — To determine to what extent, if any, the introduction of a crop of the clover family will make the application of nitrogen to the following crop unnecessary. Potatoes this year followed soy beans, and gave a yield on the no-nitrogen plots equivalent to 99.3 per cent. of that obtained on the plots to which nitrogen has been yearly applied.

III. — To determine the relative value of muriate and high-grade sulfate of potash for field crops. The results of the year indicate sulfate to be superior to the muriate for cabbages, mixed timothy and clover, and potatoes as indicated by the yield of merchantable tubers. The results with onions were indecisive as the crop failed to mature, largely, it is believed, on account of the cold summer.

IV. — *A*. To determine the relative value of nitrate of soda, sulfate of ammonia, and dried blood, used in connection with manure as sources of nitrogen for garden crops. The results indicate these materials used in amounts furnishing equal nitrogen to rank in the following order: nitrate of soda, dried blood, sulfate of ammonia. *B*. To determine the relative value of sulfate and muriate of potash for garden crops. The results of the year indicate the sulfate of potash to be the better for onions, tomatoes and celery; while the muriate has given slightly superior results with strawberries and squashes.

V. — To determine the relative value of different potash salts for field crops. The salts under comparison are high-grade sulfate, low-grade sulfate, kainite, muriate, nitrate, carbonate, and silicate. The crop of this year was clover. The potash salts giving the best yields are the silicate, high-grade sulfate, and nitrate. The most striking result brought

out is the injury to young clover in a cold, wet spring, due to potash salts containing chlorine, especially to the kainite.

VI. — To determine the relative value of phosphates used in quantities furnishing equal phosphoric acid to each plot. The crop of this year was onions; and the phosphates giving the best results, and the only ones which can be considered even fairly satisfactory, in the order of their rank, are: dissolved bone meal, fine-ground raw bone, phosphatic slag, and the steamed bone meal. Two gave results very much inferior to all others, viz., Tennessee phosphate and Florida soft phosphate.

VII. — *A*. Soil test with corn. The results of this year indicate that potash to a far greater extent than any other plant-food element controls the yield of corn. Muriate of potash alone at the rate of 160 pounds per acre annually for fourteen years gives this year a yield at the rate of 47.7 bushels of shelled grain per acre. The combination of dissolved bone-black with the same amount of muriate of potash gives a crop of 55.9 bushels of shelled grain per acre. *B*. Soil test with potatoes. The results of the year indicate that the muriate of potash on the limed portion of the field increased the crop more than either of the other fertilizer elements; but the potato crop is increased to a considerably greater extent by the use of materials furnishing phosphoric acid and nitrogen than was the corn in the other soil test.

VIII. — To determine the relative value for the production of corn and mixed grass and clover in rotation of a large application of manure, as compared with a smaller application of manure in connection with a potash salt. The crop of this year was mixed grass and clover. The manure alone gave crops somewhat larger than the combined manure and potash, but, owing to the lesser cost of the combination, the financial result is in its favor.

IX. — To determine the relative value for crop production of two fertilizer mixtures, one furnishing the important elements of plant food in the same proportion in which they are found in the average of corn fertilizers offered in our markets, the other containing less phosphoric acid and

more potash, the crops being corn and mixed grass and clover in rotation. The crop of this year was mixed grass and clover. The result is a yield at the rate of 1,520 pounds per acre more on the fertilizer mixture containing the greater amount of potash; and this superior crop is produced at a cost per acre for fertilizers of about $4 less than the combination of materials used on the other plots. The nutritive value of the hay from the plots receiving the greater amount of potash is superior to that from the other plots, on account of the greater relative abundance of clover.

X. — To determine the economic result of using in rotation on grass lands: the first year, wood ashes and nitrate of soda; the second year, ground bone, muriate of potash, and nitrate of soda: and the third year, barnyard manure. The yields amount on the average to about 2 tons per acre, produced at a cost for manure and fertilizers making their application decidedly profitable.

XI. — To determine which is the better practice, — to spread fresh manure directly on the field during late autumn or winter, or to put into large piles in the field at the same time, these piles to be spread and immediately ploughed in in the spring. The field where this experiment is tried has a moderate slope. The crop of this year was corn, and the results were on the whole quite favorable to the spring application, although the difference in the yield this year was not sufficient to repay the cost of the extra handling.

XII. — To determine whether the use of nitrate of soda for rowen is profitable. The application of nitrate to a timothy sod at rates varying from 150 to 250 pounds per acre gives a marked increase in every case, — an increase more than sufficient to cover the cost of nitrate and its application.

XIII. — Variety test with potatoes. The varieties giving yields exceeding 250 bushels of merchantable tubers per acre, mentioned in the order of productiveness, are: Beauty of Hebron (first generation from Maine seed), Beauty of Hebron (second generation from Maine seed), I. X. L., Steuben, Early Nancy, Million Dollar, Ensign Bagley,

Early Rose, Gem of Aroostook, and Daughter of Early Rose. It is significant that the old variety — the Beauty of Hebron — outranks all other varieties; while the still older Early Rose is exceeded by only 6 out of the 31 varieties.

XIV. — To determine the best nutritive ration in feeding hens for eggs. The results of the year appear to indicate that if materials carrying considerable fat are used in combination with rations in which wheat and corn respectively are most prominent, the wheat slightly surpasses the corn; but that if fat be not freely supplied in connection with such rations, the corn is superior to wheat. Corn and buckwheat compared, without materials furnishing any considerable amount of fat, give results markedly favorable to corn.

I. — The Relative Value of Manures furnishing Nitrogen. (Field A.)

A full description of the plan of the experiment in this field will be found in the twelfth annual report. The object is to determine the relative value for various crops of a few of the standard materials which may be used on the farm as a source of nitrogen. The materials under comparison are barnyard manure, nitrate of soda, sulfate of ammonia, and dried blood. These wherever used are applied in such quantity as to furnish equal amounts of nitrogen. To three plots in the field no nitrogen in any form has been applied. All the plots in the field receive the same amounts of materials furnishing phosphoric acid and potash and in liberal quantities. Barnyard manure is the source of nitrogen on one plot, nitrate of soda on two plots, sulfate of ammonia on three plots, and dried blood on two. This experiment was begun in 1890, and the crops which have been grown previous to this year in the order of succession are: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, and soy beans. As the result of all experiments previous to this year, it is found that the materials furnishing nitrogen have produced crops ranking in the following order: —

	Per Cent.
Nitrate of soda,	100.0
Barnyard manure,	91.8
Sulfate of ammonia,	90.0
Dried blood,	87.7
The plots receiving no nitrogen,	71.0

The crop for this year was potatoes, which therefore follow a leguminous crop, — the soy bean. After the beans were harvested rye was sown as a cover crop, but the season of sowing was so late that it had made but little growth when the land was ploughed for potatoes this spring. The variety of potatoes grown was Beauty of Hebron. The seed stock used was grown in northern Maine. On April 10 it was treated in the customary way in solution of corrosive sublimate for prevention of scab. The seed was then spread in a single layer in a sunny room, where it remained until May 5. The seed stock was of excellent quality, the tubers in general smooth and of good size. Before planting they were cut to pieces of two good eyes each. They were planted in rows 3 feet apart and 1 foot apart in the rows. It is a matter of regret that the stock of seed reserved for this field proved not quite sufficient. Plots 0 to 2 and a part of 3 were planted with seed also grown in Maine, of the White Maine variety. This also was treated with corrosive sublimate solution, and before planting cut to pieces of two eyes. It was not, however, budded before planting. Growth throughout the early part of the season was normal and good. The crop was sprayed four times with Bowker's Boxal, which, as in other experiments, proved effective in destroying bugs, but did not entirely prevent blight. The dates of spraying were June 19 and 28, and July 11 and 26. Much care was taken in spraying, and it is believed that the fact that blight was not entirely prevented was due to the use of nozzles which threw the spray only on the upper surfaces of the leaves. Blight was quite general, although only just beginning, on August 12. By August 27 the tops were nearly all dead, except that a few scattering plants were still green at the tips on plots 0, 1, 2 and 3, and that the top leaves of the plants were generally green on plots 5, 6 and 8. The last three plots are those, as will be seen

by the table below, to which sulfate of ammonia was applied; and it seems likely that this longer persistence of life in the tops was connected with the retarded growth due to the fact that the nitrogen of the sulfate of ammonia probably became available relatively late in the season. Digging the crop was commenced on August 29 and finished September 6. Those plots were dug first on which it was believed there was most decay. Some rotten tubers were found on all plots, those affected being generally of large size. The amount of rot, so far as can be judged, does not appear to have been affected by the nature of the fertilizers used, for we find very wide variations between plots all of which were similarly manured. The fertilizer treatment and the yields on the several plots are shown in the following table: —

Yield of Potatoes per Acre (Bushels).

Plots.	Nitrogen Fertilizer.	Merchantable.	Small.	Rotten.
0	Barnyard manure,	132.00	19.50	16.33
1	Nitrate of soda,	119.67	15.50	8.33
2	Nitrate of soda,	104.17	18.67	21.67
3	Dried blood,	136.17	24.50	27.17
4	No nitrogen,	93.33	42.50	32.67
5	Sulfate of ammonia,	129.83	35.67	1.50
6	Sulfate of ammonia,	153.83	34.67	14.50
7	No nitrogen,	116.33	50.17	19.17
8	Sulfate of ammonia,	102.00	34.00	27.00
9	No nitrogen,	119.67	40.00	9.17
10	Dried blood,	157.67	32.83	37.67

The average results are as follows: —

Fertilizer.	Merchantable (Bushels).	Small (Bushels).	Rotten (Bushels).
Average of the no-nitrogen plots (3),	109.78	44.22	20.34
Nitrate of soda plots (2),	111.92	17.09	15.00
Dried blood plots (2),	146.92	28.67	32.42
Sulfate of ammonia plots (3),	128.55	34.78	17.89

The relative standing of the different materials furnishing nitrogen, calling the one giving the largest yield 100, is as follows: —

	Per Cent.
Dried blood,	100.00
Sulfate of ammonia,	87.10
Barnyard manure,	80.68
Nitrate of soda,	69.22
No nitrogen,	83.80

The nitrate of soda stands relatively much lower than in previous experiments on this field. The past season was exceptionally rainy, and there may have been some loss of the nitrate, all of which was applied just before planting. Such loss would not, however, account for the fact that the yield on the nitrate is below that on the no-nitrogen plots; and we are compelled to conclude that the fact that normal development and ripening were interfered with by the prevalence of blight and rot has prevented the several fertilizers from exerting a full normal effect. In estimating the significance of the results, we must not, however, lose sight of the fact that the crop of last year was a legume (the soy bean), and that the great abundance of nodules upon its roots indicated that it developed under conditions making possible a very large assimilation of atmospheric nitrogen.

II. — Crops of the Clover Family (Legumes) as Nitrogen Gatherers.

This experiment is carried out in connection with experiments to determine the relative value of different materials furnishing nitrogen on Field A. Both soy beans and clover have been used previous to the present season, the former during three years and the latter for one year. The crop of both is harvested. Our object is to test, not the effect of ploughing under these crops, but simply the improvement following the introduction of each derived from their roots and stubble. Previous to the present year the results have indicated little or no improvement in the condition of the soil following the culture of the soy bean, and a very great improvement followed the turning under

of the clover sod, as shown by the fact that the potato crop of 1900 grown upon the clover sod was almost as good where no nitrogen fertilizers have been used for eleven years as it was where such fertilizer has been annually used in fairly liberal amounts. The crop in 1901 was soy beans. For the present season it was potatoes. The average yields for this year as well as for the previous years during which the experiment has continued are shown by the table: —

Effect of Leguminous Crops upon the Following Crop (Pounds).

PLOTS (EACH ONE-TENTH).	1890. Oats.	1891. Rye.	1892. Soy Bean.	1893. Oats.	1894. Soy Bean.	1895. Oats.	1896. Soy Bean.
Nitrogen plots,	343	484	1,965	598	620	494	1,740
No-nitrogen plots,	290	421	1,443	540	452	370	1,143

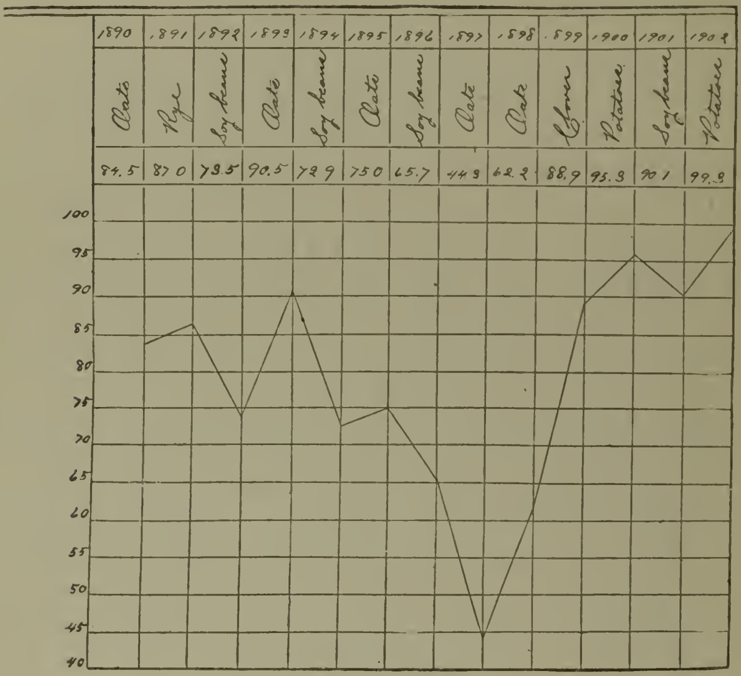
Effect of Leguminous Crops upon the Following Crop (Pounds) — Concluded.

PLOTS (EACH ONE-TENTH).	1897. Oats.	1898. Oats.	1899. Clover.	1900. Potatoes.	1901. Soy Bean.	1902. Potatoes.
Nitrogen plots,	445	254	413	1,316	442.2[1]	1,053.6
No-nitrogen plots,	197	158	367	1,254	398.3[1]	1,046.0

[1] Dry beans and straw.

There are three plots in the field which have received neither manure nor fertilizer supplying nitrogen since 1884, and the figures showing yields are the averages for these plots. The figures for the nitrogen plots show the average products of the eight plots in the field which have yearly received an application of materials furnishing nitrogen in fairly liberal amounts. These materials are as follows: barnyard manure, one plot; nitrate of soda, two plots; sulfate of ammonia, three plots; and dried blood, two plots. At the rates at which they are used, these materials furnish 45 pounds of nitrogen per acre, and they are so used that

each plot receiving a nitrogen fertilizer receives annually the same number of pounds of nitrogen. The past season is the eighteenth since the no-nitrogen plots have been manured with anything containing nitrogen. The curve below shows the per cent. which the yield on these plots constitutes of the yield on the plots manured with nitrogen.



That the crop of potatoes on the no-nitrogen plots this year amounts to 99.3 per cent. of the crop on the plots receiving nitrogen is a fact of much significance. In the earlier years of this experiment, as has been stated, the crops following soy beans have not appeared to derive any considerable benefit from the roots and stubble of this crop. For this year it is believed that we must conclude the benefit is considerable. This difference in the after-effect of the soy beans is possibly explained in part by the fact that the bacteria, whose presence is essential to the acquisition of atmospheric nitrogen, are now more abundant in this soil than during the earlier years when soy beans were grown ;

but it may be that the relative standing of the no-nitrogen plots is higher than it would have been had the crop of potatoes grown to normal maturity. It will be remembered that blight and rot prevailed to a considerable extent, and these would naturally injure the potatoes with the ranker growth more than those where the growth was less luxuriant. It does not seem, therefore, that we are justified in concluding that the after-effect of the soy beans is as useful as the relation between the figures appears to indicate.

III. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

The object of this experiment, which has been in progress since 1892, is to determine the relative value for different crops of the two leading and cheapest sources of potash, viz., muriate and high-grade sulfate. These salts are used in equal quantities continuously upon the same land. The field contains eleven plots, of approximately one-eighth of an acre each. Of these, six have been yearly manured with muriate of potash and five with the high-grade sulfate. From 1892 to 1899 inclusive these salts were used at the rate of 400 pounds per acre; since 1900 the rate of application has been 250 pounds per acre. Fine-ground bone at the rate of 600 pounds per acre has been yearly applied to all plots. Various crops have been grown in rotation, including potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans, and cabbages. Most of these crops have been grown during several different years. All have with few exceptions given uniformly large yields. The results to date may be summarized as follows: among the crops grown, the potatoes, clovers, cabbages, and soy beans have usually done much the best on the sulfate of potash: the yield of corn, grasses, oats, barley, vetches and sugar beets has been about equally good on the two salts; the quality of the potatoes and sugar beets produced on the sulfate of potash plots has been distinctly better than that of the crops produced on the muriate of potash.

The crops of the past year have been mixed timothy and clover, cabbages, potatoes, and onions.

1. Timothy and Clover (Sulfate v. Muriate of Potash).

Mixed timothy and clover occupied two plots which were seeded in July, 1901. The proportion of clover on the sulfate of potash plot was distinctly greater than on the other. The variety of clover was the alsike. The yields are shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Timothy and Clover Hay per Acre (Pounds).

	Muriate of Potash.	High-grade Sulfate of Potash.
Hay,	4,710	4,725
Rowen,	1,745	1,997
Totals,	6,455	6,722

It will be seen that there is no considerable difference in the amount of hay yielded by the two potash salts. The first crop, indeed, in which of course timothy was relatively abundant, was practically equal upon the two. There is more difference in the rowen crops, which is without doubt a consequence of the better growth of the clover (which furnishes most of the rowen) on the sulfate of potash. Our results, then, are confirmatory of those in previous years, which have tended to show that, especially in cool and wet seasons, clover does better upon sulfate than upon muriate of potash. The experiment of the present season upon another of our fields (Field G), to be reported later, is also strikingly confirmatory of this general principle.

2. Cabbages.

Cabbages occupied two plots (17 and 18) on which clover was grown last year; and a considerable growth of mixed white and alsike clover, with some sorrel and weeds, was ploughed in a few days before planting the cabbages. The variety of cabbage grown was the All Seasons, from Gregory & Son, Marblehead. The seed was planted in hills 3 by 2½ feet apart on June 16. A very heavy shower interrupted the work, and so packed the soil on the muriate

of potash plot, where the planting had been completed, that germination was imperfect; while on the other plot, where the seed was put in after the shower, the stand of plants was good. When the plants were finally thinned and vacancies filled, it was found necessary to use some plants from the sulfate of potash plot to fill vacancies on the other plot. The summer proved so cool that the crop did not fully mature on either plot, as growth was unusually slow. The yields are shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Cabbages, Yields per Acre.

	Muriate of Potash.	High-grade Sulfate of Potash.
Hard heads (number),	2,648	3,420
Hard heads (pounds),	26,063	35,550
Soft heads (pounds),	22,650	18,263

It will be noticed that the total yield of hard heads on the sulfate of potash was materially greater than on the other plot. The merchantable value of the hard heads on the two plots, at ½ cent per pound was, respectively, for the muriate of potash $130.32, for the sulfate $177.75; the sulfate, therefore, gave a crop worth $47.43 per acre more than the muriate. The sulfate in the quantity used cost less than 70 cents per acre more than the muriate. The result of this year is in exact agreement with the result obtained in 1899, when, as this year, the season was rather cold and rainy. When the seasons are hot and relatively dry, the difference between the two salts is comparatively small, and sometimes the muriate gives a slightly better crop than the sulfate. It seems evident, however, that on all except the lightest soils the sulfate is the safer of the two potash salts to employ for the cabbage crop.

3. *Potatoes* (*Sulfate v. Muriate of Potash*).

The potatoes grown in this experiment occupied two plots, 15 and 16. For the two preceding years these plots had been in clover, the clover sod being turned on April 15.

The variety of potatoes was Beauty of Hebron, and the seed stock was purchased in northern Maine. It was prepared for planting by treating with corrosive sublimate on April 10, exposed in a light room in a single layer until April 22, and then cut into pieces of two eyes each. The pieces were planted 1 foot apart in rows 3 feet apart the same day the tubers were cut. The crop was thoroughly cared for throughout the season. It was sprayed with Bowker's prepared insecticide and fungicide four times, June 19 and 28, and July 11 and 26. As in our other experiments, the spraying proved thoroughly effective in destroying bugs, but not entirely so in preventing blight and rot. The growth on both plots was vigorous, and from a very early period there was a marked difference in the shade of green on the two; the vines on the sulfate of potash plot were of a dark-green color, those on the muriate of potash plot were of a light-yellowish — or pea-green color. This difference persisted until the crops began to ripen. On August 5 the tops were generally beginning to show signs of ripeness. On the 12th, blight was general, though not apparently severe. The tops were entirely dead on August 29, on which date the potatoes were dug. They were divided into two grades as to size, the potatoes classed as small including those estimated to be below 2 ounces in weight. There was considerable rot, as a rule of the larger tubers only. The total weight of the decayed potatoes on the muriate of potash plot was 50 pounds, on the sulfate of potash plot 314 pounds. In the estimate of total product these tubers are included with the merchantable. The yields were at the rates per acre shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Potatoes, Yield per Acre (Bushels).

	Muriate of Potash.	High-grade Sulfate of Potash.
Potatoes, merchantable,	208	215
Potatoes, small,	53	39
Totals,	261	254

The total yield on the two plots is nearly the same. The crop on the sulfate of potash averaged of larger size than that on the muriate, but there was most decay on the sulfate. Whether this fact has any special significance it is impossible to say, without repeating the experiment.

4. *Onions (Sulfate v. Muriate of Potash).*

The onions grown in this experiment occupied two plots, 19 and 20. The crop of last year on these plots was cabbages, with winter rye as a cover crop, sown before the cabbages were harvested. The variety of onions was Danvers Yellow Globe. The seed was obtained from Gregory & Son, Marblehead, 1901; it was therefore one year old. It was sown in the thoroughly prepared soil in rows 14 inches apart on April 24. Growth throughout the earlier part of the season was very slow, and the final crop was poor. The fertilizers usually employed on this series of plots were supplemented by the application of a combined form of quick-lime and nitrate of soda, known as "niterlime,"[1] at the rate of 175 pounds per acre. This was applied on July 12 and cultivated in. Soon after its application growth became much more rapid; but whether this was due chiefly to the somewhat more seasonable weather which then prevailed, or to the application of niterlime, we cannot feel certain. The onions were pulled on September 23, those on the sulfate of potash being more nearly mature than those on the other plot. The yield per acre, in bushels of sound onions and pounds of scallions, is shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Onions, Yield per Acre.

	Muriate of Potash.	High-grade Sulfate of Potash.
Onions (bushels),	110	75
Scallions (pounds),	10,811	8,828

[1] Niterlime contains: nitrogen, about 10.5 per cent.; and lime, about 20 per cent.

It will be seen that the muriate of potash has given the larger yield; but, since the onions on the sulfate were riper than those on the muriate, the figures probably have no special significance.

IV. — Fertilizers for Garden Crops. (Field C.)

The conclusions now presented are based upon the results of experiments which have been in progress since 1891. From that date to 1898 chemical fertilizers alone were used. During the past five years stable manure has been applied in equal quantities (at the rate of 30 tons per acre) to each of the plots, while the chemical fertilizers have been used in the same amounts and applied to the same plots as at first. The crops grown during this series of years have included all important out-door crops: spinach, lettuce, onions, garden peas, table beets, early cabbages, late cabbages, potatoes, tomatoes, squashes, turnips, sweet corn, celery, and one small fruit, — strawberries. Two of the perennial garden crops, asparagus and rhubarb, have now been planted, but these will not be discussed in the present report. Experiments have been planned with reference to throwing light especially upon two points: —

A. The relative value of nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen.

B. The relative value of sulfate of potash and muriate of potash.

These two points will be separately discussed.

A. — The Relative Value of Nitrate of Soda, Sulfate of Ammonia and Dried Blood as Sources of Nitrogen.

The three fertilizers used as sources of nitrogen have from the first been applied in such amounts as to furnish equal nitrogen to each plot, and each fertilizer is always applied to the same plot. Each of the nitrogen fertilizers is used on two plots, — on one with sulfate of potash, on the other with muriate. Dissolved bone-black as a source of phosphoric acid is applied in equal quantities to all plots. The results previous to this year may be thus summarized: —

For the early crops, *i.e.*, the crops making most of their

growth before midsummer, including onions, lettuce, table beets, garden peas, and strawberries, the nitrate of soda has been found the most effective source of nitrogen. The relative standing of the different nitrogen fertilizers is as follows : —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	92.7
Sulfate of ammonia,	54.8

For late crops, including cabbages, turnips, and celery, the relative standing is : —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	98.7
Sulphate of ammonia,	77.5

The average rate of yield per plot for each of the nitrogen fertilizers for the present season is shown in the following table : —

Nitrogen Fertilizers compared for Garden Crops. — Yield per Plot (Pounds).

Average of Two Plots.	Onions.		Tomatoes.		Strawberries.	Celery.	Squashes.
	Ripe.	Scallions.	Ripe.	Green.			
Nitrate of soda,	367.5	29	235.9	264	125.8	360	841.3
Sulfate of ammonia,	209.5	94	242.1	345	128.4	180	819.6
Dried blood,	357.0	34	403.7	269	146.4	295	807.4

It will be seen that for most of the crops the results are similar to the average results of preceding years. Nitrate of soda, however, stands relatively somewhat lower. Combining the results of this year with those of previous years, the relative standing of the different fertilizers used as sources of nitrogen is as follows : —

For the early crops, including onions and strawberries : —

	Per Cent
Nitrate of soda,	100.0
Dried blood,	93.7
Sulfate of ammonia,	57.3

For the late crops, including tomatoes, celery, and squashes: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	99.0
Sulfate of ammonia,	78.4

Since nitrate of soda furnishes a pound of nitrogen at lower cost than any other of the fairly concentrated fertilizers, it becomes very evident, in view of our results, that it should be used as the source of this element as largely as the nature of the conditions permits. It should be remembered, as has been stated in previous reports, that the soil of Field C is a moderately retentive loam. Upon a lighter soil the superiority of the nitrate would probably be less marked. It must again be pointed out that experiments here, as elsewhere, make it very probable that the relative standing of the sulfate of ammonia would be bettered by making a heavy application of lime to the plots where it is used. Since, however, the pound of nitrogen costs more in the sulfate of ammonia than in either the nitrate or the dried blood, it would seem that there can be little probability that the selection of this nitrogen fertilizer is usually wise. Its physical properties, it is true, are such that it is more readily and conveniently used in mixtures with other materials than the nitrate, since the latter attracts moisture, while the sulfate of ammonia does not do this to any considerable extent. If, however, nitrate of soda which has been recently reground and which has been stored in a dry place be used, and if the mixture can be applied soon after it is made, there is little difficulty in employing nitrate.

B. — The Relative Value of Sulfate and Muriate of Potash for Garden Crops.

The history of the plots where these two potash salts are under comparison has been outlined under section *A*. The crops are the same as those which have been named under that section. Each potash salt is used on three plots, *i.e.*, with each of the three nitrogen fertilizers. The results of the past year are shown in the following table: —

Sulfate and Muriate of Potash compared as Fertilizers for Garden Crops. — Yield per Plot (Pounds).

Average of Three Plots.	Onions.	Tomatoes.	Strawberries.	Celery.	Squashes.
Muriate of potash,	360	579.8	135.7	270	879.7
High-grade sulfate of potash,	367	593.0	131.4	287	766.2

In the discussion of the relative standing of these two potash salts, the same crops are included respectively under the headings early and late as those specified in section *A*. The relative standing of these two salts at the beginning of the present year is shown in the following table: —

Fertilizers.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.0	100.0
Muriate of potash,	92.6	103.0

Including the crops of the past year, the relative standing of the two potash salts is as follows: —

Fertilizers.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.0	100.0
Muriate of potash,	93.2	102.9

Attention is called to the fact that the results of this year are in exact accord with those of earlier years. The sulfate of potash proves considerably superior to the muriate for the crops making most of their growth early in the season, while for those making their growth in the latter part of the season the muriate is slightly superior.

V. — Comparison of Different Potash Salts for Field Crops. (Field G.)

Since 1898 the following potash salts have been under comparison for various field crops: kainite, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate, and

silicate. Each is applied annually to the same plot, and all are used in such quantities as to furnish equal potash to each plot. All plots are equally manured with materials furnishing nitrogen and phosphoric acid. There are forty plots, in five series of eight plots each, each series including a no-potash plot and one for each potash salt used. The area per plot is about one-fortieth of an acre. The crops on this land last year were winter wheat on one series and ensilage corn on the other four series. On the series occupied by the winter wheat, clover was sown after reploughing, the last of July. On the four series occupied by corn last year clover was sown in the corn early in August. The clover on the series following wheat got an excellent start, and went through the winter well. The clover on the other series, owing to the dense shade of the corn, which was very heavy, made much less growth, and was to a considerable extent winter-killed. On these plots, Nos. 9 to 40, it was necessary to sow additional seed this spring. This was done on March 26, when the soil and weather conditions were favorable. The seed sown at this time started well. The usual fertilizers were applied this spring on April 25. The crop on all the plots was cut on June 11. That on the series which followed wheat was well grown, and the product of each plot was separately weighed. The product of the other plots was much mixed with weeds, which, on account of the winter-killing, were able to make considerable growth; and it was not considered that the weights would have much value, as indicating the relative yield of clover. Before the clover was cut, however, the plots were carefully examined. It was found that on each of the plots to which kainite had been applied the condition of the young clover was much inferior to that of the clover on the other plots. The color was poor, while many of the plants appeared to be dying. This difference was not apparent between the clover plants which had survived the winter on the different plots. Examination disclosed the further fact that there was a somewhat similar degree of inferiority in the condition of the young clover on all of the plots which had received an application either of the low-grade sulfate of potash or of muriate of potash, as compared with that on the other plots.

Indeed, at this time the young clover on all the kainite, low-grade sulfate and muriate of potash plots appeared to be inferior to that on the plots which had received no potash. By the middle of the season there were many places in all these plots on which there was no clover. Before the end of the season, however, such clover plants on these plots as survived became perfectly healthy, and were characterized by a marked degree of vigor. It cannot be doubted, in view of the unfavorable results which have been previously obtained in our experiments where muriate of potash has been used for clover, that it is the chlorides in the three fertilizers which cause the injury. Chlorides may produce this effect either because of the increased loss of lime which their use leads to, or possibly because of the fact that their continued use brings the soil into an acid condition. Either deficiency of lime or presence of free acid is known to be decidedly unfavorable to the growth of clover.

All the plots in the field were cut twice subsequent to June 11, viz., on August 4 and October 10. On the first date there was a moderate growth of small weeds and a few large ones on the plots on which the clover was poor, *i.e.*, on the kainite, muriate of potash, and low-grade sulfate of potash plots. These, as far as practicable, were thrown out. In estimating the significance of the differences in yield, however, it should be remembered that the real difference in the condition and growth of the clover was undoubtedly greater than the figures indicate, as where the clover is weakest the weeds are most numerous, and it is impossible to separate them all. The crops cut were carefully cured in cocks without loss of leaf, and the hay was well dried when weighed. The tables show the rates of yield per acre and the averages for the last two cuttings of the several potash salts: —

Clover. — Yield per Acre (Pounds).

Plots.	Potash Salt.	Hay.	First Cut, Rowen.	Second Cut, Rowen.	Totals.
1	No potash,	2,458	2,078	1,273	5,809
2	Kainite,	2,681	2,491	1,475	6,647
3	High-grade sulfate,	2,681	2,301	1,564	6,546

Clover. — Yield per Acre (Pounds) — Concluded.

Plots.	POTASH SALT.	Hay.	First Cut, Rowen.	Second Cut, Rowen.	Totals.
4	Low-grade sulfate,	2,904	2,324	1,430	6,658
5	Muriate,	2,904	2,188	1,609	6,701
6	Nitrate,	3,128	2,156	1,475	6,759
7	Carbonate,	3,128	2,391	1,430	6,949
8	Silicate,	3,128	2,480	1,541	7,149
9	No potash,	–	2,100	1,273	3,373
10	Kainite,	–	1,966	849	2,815
11	High-grade sulfate,	–	2,569	1,296	3,865
12	Low-grade sulfate,	–	2,458	1,229	3,687
13	Muriate,	–	2,414	1,162	3,576
14	Nitrate,	–	2,670	1,162	3,832
15	Carbonate,	–	2,458	1,385	3,843
16	Silicate,	–	2,793	1,206	3,999
17	No potash,	–	2,435	670	3,105
18	Kainite,	–	2,145	581	2,726
19	High-grade sulfate,	–	2,636	983	3,619
20	Low-grade sulfate,	–	2,726	961	3,687
21	Muriate,	–	2,547	1,340	3,887
22	Nitrate,	–	2,815	1,251	4,066
23	Carbonate,	–	2,591	1,117	3,708
24	Silicate,	–	2,726	1,251	3,977
25	No potash,	–	2,234	626	2,860
26	Kainite,	–	2,324	849	3,173
27	High-grade sulfate,	–	2,815	1,206	4,021
28	Low-grade sulfate,	–	2,525	983	3,508
29	Muriate,	–	2,681	938	3,619
30	Nitrate,	–	2,748	1,117	3,865
31	Carbonate,	–	2,591	1,162	3,753
32	Silicate,	–	2,860	1,340	4,200
33	No potash,	–	2,435	849	3,284
34	Kainite,	–	2,100	760	2,860
35	High-grade sulfate,	–	2,703	1,251	3,954
36	Low-grade sulfate,	–	2,636	1,162	3,798
37	Muriate,	–	2,949	1,072	4,021
38	Nitrate,	–	2,681	1,117	3,798
39	Carbonate,	–	2,681	983	3,664
40	Silicate,	–	2,502	849	3,351

Clover Rowen. — Average Yield per Acre (Pounds).

Potash Salt.	First Cut, Rowen.	Second Cut, Rowen.
No potash (1, 9, 17, 25, 33),	2,256	938
Kainite (2, 10, 18, 26, 34),	2,205	903
High-grade sulfate (3, 11, 19, 27, 35),	2,665	1,260
Low-grade sulfate (4, 12, 20, 28, 36),	2,534	1,153
Muriate (5, 13, 21, 29, 37),	2,556	1,224
Nitrate (6, 14, 22, 30, 38),	2,614	1,224
Carbonate (7, 15, 23, 31, 39),	2,542	1,215
Silicate (8, 16, 24, 32, 40),	2,672	1,237

The figures call for little comment. They strikingly show the marked inferiority of the product on the plot receiving kainite. Not only is the average product on this plot lower than the yield on any of the other potash salts, — but it is lower in every series except one than the yield on the plot receiving no potash. The potash salt giving the highest average total yield is the silicate, — almost as good is the high-grade sulfate, — while the yield on the nitrate muriate and carbonate is not far behind.

VI. — Comparison of Phosphates on the Basis of Equal Application of Phosphoric Acid.

In this experiment, which has been in progress six years, we have under comparison the following phosphates: apatite, South Carolina rock phosphate, Florida soft phosphate, phosphatic slag, Tennessee phosphate, dissolved bone-black, raw bone, dissolved bone, steamed bone, and acid phosphate. The phosphates are all applied in the finely ground form, being carefully spread broadcast after ploughing in the spring, and harrowed in. Three plots in the field have received no phosphoric acid in any form since the beginning of the experiment. The plots are one-eighth of an acre each in area. The phosphates yearly applied are used in quantities sufficient to furnish actual phosphoric acid at the rate of 96 pounds to the acre. All plots are manured alike, with materials furnishing nitrogen and potash in available forms and in equal amounts to each. The materials regularly used furnish nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. During the past

year every plot in the field has received an extra application furnishing nitrogen during the growth of the crop. The material used was niterlime, a combination of nitrate of soda and quicklime, containing 10.44 per cent. nitrogen and 20.41 per cent. lime. This was applied broadcast on July 2, at the rate of 176 pounds per acre, and cultivated in.

The preceding crops have been: corn, cabbages, corn, and in 1900 oats for hay, and Hungarian grass also cut for hay, and onions. With the exception of the onions, all these crops have given large yields, even on the three plots in the field which have received no application of phosphoric acid. Attention is once more called to the fact that the soil of plot 1 seems to have been naturally in a much higher condition of fertility than that of any other plot in the field. In estimating the significance of the results, therefore, the yield of this plot should be disregarded. A more correct indication of the effect of each of the phosphates on plots 2 to 6 is afforded by comparing the yields of those plots with the yield on plot 7. It is, however, without doubt true that the soil from plot 7 towards plot 1 improves gradually in physical condition and natural fertility. The crop the present year has been onions. These throughout this part of the State have generally been a poor crop this year. Our yields are comparatively small even on the best plots. The results are given in the table: —

Onions on Plots with Equal Amounts of Phosphoric Acid.

Plots.	Fertilizer.	Onions (Bushels per Acre).	Scallions (Pounds per Acre).
1	No phosphate,	195.7	8,560
2	Apatite,	101.7	8,480
3	South Carolina rock phosphate,	121.8	9,360
4	Florida soft phosphate,	52.3	6,880
5	Phosphatic slag,	252.0	5,600
6	Tennessee phosphate,	44.6	6,960
7	No phosphate,	50.5	5,360
8	Dissolved bone-black,	173.8	5,640
9	Raw bone,	301.4	4,144
10	Dissolved bone meal,	388.9	5,400
11	Steamed bone meal,	243.8	5,840
12	Acid phosphate,	159.4	6,560
13	No phosphate,	26.2	6,600

Up to the time when onions were introduced as a crop on this field, the leading conclusions drawn from the experiments were the following: —

1. The phosphatic slag has apparently furnished phosphoric acid in an exceedingly available form, the yield on the plot receiving the slag being almost equal to that on the dissolved bone-black.

2. The Florida soft phosphate has given the lowest yields of any plot receiving phosphoric acid.

3. Steamed bone meal appears to be inferior in availability to raw bone meal.

For last year the phosphates giving the largest yields of sound onions, mentioned in the order of their rank, were: raw bone, phosphatic slag, South Carolina rock phosphate, apatite, dissolved bone meal, and dissolved bone-black. All others gave yields under 200 bushels to the acre.

Examination of the table shows that the results are in general similar to those of last year; the differences, however, are much greater and the apatite and South Carolina rock phosphate take a relatively much lower rank. The dissolved bone meal gives the largest crop; raw bone ranks next; while the phosphatic slag stands next in order, with steamed bone meal not far behind.

The proper ripening of the onion crop, as shown by this as well as other of our experiments, appears to be dependent in very large measure upon the presence of a liberal supply of highly available phosphoric acid. It appears very doubtful, therefore, whether it is likely ever to prove expedient to depend upon natural rock phosphates or untreated bone as a source of phosphoric acid for this crop.

VII. — Soil Tests.

During the past season we have conducted three soil tests, — two upon our own grounds, both in continuation of previous work upon the same fields, and one on the farm of A. M. Lyman of Montague. In these experiments the fertilizers are used in accordance with the co-operative plan for soil tests adopted in Washington in 1889. Each plot receives annually the same kinds of fertilizers, and

usually in the same amounts. These experiments are not calculated to secure the production of heavy crops, but are designed rather to throw light upon the general question as to how the different crops should be manured for the most profitable results. The fertilizers are so applied that it becomes possible to determine with much accuracy the effects of each of the leading elements of plant food. Every fertilizer used, whether applied by itself or in connection with one or both of the other fertilizer materials, is always applied in the same quantities. Fertilizers and manures are always applied broadcast after ploughing, and harrowed in. The following table shows the kinds and usual amounts per acre: —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone-black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 400 pounds.
Lime, 400 pounds.
Manure, 5 cords.

A. — Soil Test with Corn (South Acre), Amherst.

This acre has been used in soil tests for fourteen years, beginning in 1889. The crops in successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, and this year corn once more. Since 1889 this field has therefore borne six corn crops, and during this time it has been four years in grass.

It will be noticed that the crop last year was grass. The sod was turned on April 12. The land was thoroughly harrowed, twice before sowing the fertilizer and once after. The variety of corn was Sibley's Pride of the North. It was planted in drills, 3½ feet apart, on May 22. The season was cold and unfavorable to corn, but in spite of this fact the crop made very good growth upon the four plots to which potash has been yearly applied and upon the plot which has been yearly manured. Four of the plots in this field have received no manure nor fertilizer throughout the entire fourteen years, and these show a high degree of exhaustion, — indeed, these produced scarcely any sound

grain this year. The crop, however, is not yet sufficiently dried to shell; and calculation, allowing 90 pounds of ears, as weighed November 22, to a bushel, shows that the average apparent yield is at the rate of 9.7 bushels per acre. The actual yield of grain is believed to be under 4 bushels per acre. The table shows the manuring of the several plots, the rate of yield, and the gain or loss per acre compared with the nothing plots: —

Corn. — South Acre Soil Test, 1902.

Plots.	Fertilizer used.	Yield per Acre. Corn (Bushels, 90 Pounds).	Yield per Acre. Stover (Pounds).	Gain or Loss per Acre, compared with Nothing Plots. Corn (Bushels, 90 Pounds).	Gain or Loss per Acre, compared with Nothing Plots. Stover (Pounds).
1	Nitrate of soda,	7.3	1,180	—3.1	—300
2	Dissolved bone-black,	11.4	1.780	1.0	300
3	Nothing,	10.4	1,480	-	-
4	Muriate of potash,	47.7	4,760	37.3	3,507
5	Lime,	4.9	860	—5.5	—167
6	Nothing,	10.4	800	-	-
7	Manure,	68.7	6,220	58.3	5,420
8	Nitrate of soda and dissolved bone-black.	11.2	1,380	2.0	20
9	Nothing,	9.2	1,360	-	-
10	Nitrate of soda and muriate of potash.	53.4	3,540	44.3	2,200
11	Dissolved bone-black and muriate of potash.	55.9	4,640	47.0	3,320
12	Nothing,	8.8	1,300	-	-
13	Plaster,	14.6	1,880	5.8	580
14	Nitrate of soda, dissolved bone-black and muriate of potash.	56.2	4,540	47.4	3,240

The effect of each of the three elements of plant food — nitrogen, phosphoric acid and potash — is more clearly brought out in the tables which follow: —

	Results of the Addition of Nitrogen to — Nothing.	Phosphoric Acid.	Potash.	Phosphoric Acid and Potash.	Average Results.
Corn (bushels),	—3.1	1.0	7.0	.4	1.3
Stover (pounds),	—300	—280	—1,307	—80	—492

Value of decrease, ... $0 45
Financial result (loss), ... 3 65

	Results of the Addition of Phosphoric Acid to—				
	Nothing.	Nitrogen.	Potash.	Nitrogen and Potash.	Average Results.
Corn (bushels),	1.0	5.1	9.7	3.1	4.7
Stover (pounds),	300	320	—187	1,040	368

Value of increase, ... $3 74
Financial result (gain), ... 54

	Results of the Addition of Potash to—				
	Nothing.	Nitrogen.	Phosphoric Acid.	Nitrogen and Phosphoric Acid.	Average Results.
Corn (bushels),	37.3	47.4	46.0	45.4	44.0
Stover (pounds),	3,507	2,500	3,020	3,220	3,062

Value of increase, ... $34 06
Financial result (gain), ... 30 86

	Results of the Addition to Nothing of—			
	Lime.	Manure.	Plaster.	Complete Fertilizer.
Corn (bushels),	—5.5	58.3	5.8	47.4
Stover (pounds),	—167	5,420	580	3,240
Value of increment,	-	$48 53	$4 93	$36 54
Value decrease,	$3 72	-	-	-
Financial result,	$6 12 loss.	$23 53 gain.	$1 33 gain.	$26 94 gain.

The Effect of the Nitrogen. — It will be noticed that the employment of nitrate of soda alone (nitrogen) gives a crop which is actually less than that produced where no fertilizers are used. This variation is very likely accidental, as it can hardly be supposed that the nitrate is actually injurious. When used with potash alone, the nitrate gives a moderate increase in the crop. The average result is an increase of a little more than a bushel of grain, but a decrease of nearly 500 pounds in stover. The nitrate does not pay for itself, on either of the four plots to which it was applied; for the cost of the 160 pounds is $3.60, and on the only plot where the increase in grain is sufficient to

be worth this sum there is a decrease in the amount of stover, which brings the net increased value below the cost of the nitrate.

The Effect of the Phosphoric Acid. — Dissolved bone-black (phosphoric acid) used alone produced an insignificant increase. In the different combinations the results of its use indicate it to be moderately beneficial. The best result is secured where it is employed in connection with potash. The cost of the dissolved bone-black wherever employed was at the rate of about $3.20 per acre. The average increase in crop is sufficient to barely cover this amount. Particular attention is called to the splendid crop produced where dissolved bone-black and muriate of potash are used together. The combination of these two fertilizers without nitrogen apparently suffices, under the system of rotation which has been followed, to fully maintain the productiveness of this plot. Last year its yield was at the rate of 1,900 pounds of hay to the acre in the first crop and 1,500 pounds of rowen in the second crop. As was pointed out last year, this splendid product is undoubtedly due to the capacity which clover grown in mixture with the grasses possesses to draw the needed nitrogen from the air. The advantage obtained by this system of manuring is, however, not exhausted when we have taken the hay crops; for, as shown by the yield of corn this year of almost 56 bushels of sound grain to the acre, the corn crop which requires a large amount of nitrogen (which, so far as we know, must be taken from the soil), is able to derive the needed quantity of this element from the products of the decay of the clover roots and stubble. The expenditure for fertilizers applied to this plot has been at the rate of about $6.40 per acre, and for this sum we have this year nearly 56 bushels of corn and more than 2½ tons of stover. Moreover, the beneficial effects of this system of manuring appear to be cumulative. The productivity of this plot shows not the slightest signs of decrease after fourteen years, during which time neither manure nor fertilizer furnishing a single ounce of nitrogen has been applied. In view of the results upon other plots, it cannot be doubted that the increased yield on this plot is

due in very large measure to the potash employed, but the dissolved bone-black is also evidently useful.

The Effect of the Potash. — It will be noticed that wherever potash is applied, whether alone or in combination with either one or both of the other fertilizers, the result is a large yield. Potash is evidently the dominant plant food element on this soil for corn. The increase where this element is used alone is at the rate of more than 37 bushels to the acre; the average increase, at the rate of 44 bushels to the acre. The potash used costs at the rate of $3.20 per acre. This amount is covered many times over by the increase in the crop.

The Effect of the Manure. — The manure alone gives a large crop, — considerably larger than on any other plot. That this should be true is natural, in view of the fact that the manure at the rate at which it is applied furnishes a larger amount of plant food than is furnished in the fertilizers. It also tends to keep up the supply of humus in the soil, and this, as is well understood, is highly beneficial in many ways. The yearly cost of the manure applied is, however, at the rate of about $25 per acre, while the complete fertilizer used on plot 14 costs only $10.

The results with corn this year are entirely similar in kind to those which have been obtained in the earlier years in which corn has been grown on this piece of land. They show very conclusively that on such land corn can be cheaply grown by the use of fertilizers alone, and they demonstrate conclusively that potash should be a very prominent constituent. In view of the fact that the fertilizers generally used by the farmers of the State for corn usually contain far more phosphoric acid than potash, these results appear to be well worth attention. The important question naturally at once arises, "How far are the requirements of the corn crop on the farms in other parts of the State similar to those shown by these experiments?" In answer to this question, attention is called to the results of similar experiments in various parts of the State, which have been published in Bulletins Nos. 9 and 14 of this station. These results indicate that in most localities the potash in fertilizers appears

to have a greater effect in increasing the corn crop than either of the other prominent elements. Especially has this been found to be the case on the better soils of the State. The results upon light and poor soils in Yarmouth, Freetown and Marblehead have shown but small increase for any of the fertilizers used. On such soils farmyard manures prove much the most effective. On the soils with good physical characteristics, *i.e.*, soils on which crops are not likely to suffer excessively in hot, dry weather, and especially if the soil is one which is in a fair state of fertility, the increase due to potash has always been found to be striking, and it is believed that farmers should see to it that this element is more largely supplied to this crop.

B. — Soil Test with Potatoes (North Acre).

The field on which this test was carried out has been used in similar tests with various crops for thirteen years, beginning in 1890. The crops grown in order of succession include potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and rutabaga turnips, potatoes, and onions, for four years (1898 to 1901 inclusive).

Rye was sown a short time before the onion crop of last year was pulled, in the hope of producing a crop which would serve as winter cover, and to prevent washing, to which this field is liable. This object was only in part accomplished, as the rye sown on the surface did not make a perfect start. There was considerable washing, as a result of heavy storms in March. It is not believed, however, that this was of such a character as seriously to interfere with the accuracy of our fertilizer tests, for it was for the most part with and not across plots. The several plots in this field have been manured in accordance with the usual soil test plan, with the exception that double quantities of all fertilizer materials were used during the years when onions have been grown, as well as this year. In one other respect the treatment of this field has been peculiar. The lower half of all plots received an application of lime in the spring of 1898 at the rate of 1 ton to the acre. The nitrate used during the present season was put on in two applica-

tions, — one-half applied broadcast just before planting the seed, the other half scattered about the plants and cultivated in on June 30, at which time the crop was about half grown. The field was ploughed on May 7, at which time the rye had made considerable growth. There were marked differences on the different plots, but no clearly defined difference beween the limed and unlimed portions of the several plots. The fertilizers in double the usual amounts were spread broadcast on May 12 and immediately harrowed in. The variety of potatoes planted was the Delaware, the seed being grown in the adjoining town of Hadley. In preparation for planting the seed was soaked in a solution of corrosive sublimate, for the prevention of scab. It was then dried, and the tubers were cut into pieces with two good eyes each, and planted at once. The date of planting was May 13. The potatoes started well, the crop was thoroughly cared for, and there were no accidental conditions recognized as interfering with the normal development of any of the plots. The potatoes were sprayed twice, — on July 11 with Bowker's Boxal, and on July 26 with Bowker's Bodo, to which a suitable quantity of Paris green for destruction of bugs was added. Both sprayings were effective in destroying bugs but not fully effective in preventing blight, which, however, was not serious on this field, where the growth of the tops was comparatively light. There was no rot whatever, although this disease was prevalent on similar soils in the immediate neighborhood. The crop was dug on September 8 and 9. All tubers were smooth, but of rather small average size; they were, however, of excellent quality. The following tables show the fertilizers applied to the several plots, the yields per acre, and the gain or loss compared with the nothing plots: —

Potatoes. — North Acre Soil Test (Unlimed), 1902.

Plots.	Fertilizers used.	Yield per Acre (Bushels).		Gain or Loss per Acre compared with Nothing Plots (Bushels).	
		Merchantable.	Small.	Merchantable.	Small.
1	Nothing,	27.7	24.0	-	-
2	Nitrate of soda,	30.0	20.7	1.1	—2.9
3	Dissolved bone-black,	39.3	20.0	9.2	—3.1
4	Nothing,	31.3	22.7	-	-
5	Muriate of potash,	58.0	15.3	25.7	—9.1
6	Nitrate of soda and dissolved bone-black.	69.3	28.7	36.0	2.7
7	Nitrate of soda and muriate of potash.	51.3	26.0	17.0	—1.7
8	Nothing,	35.3	29.3	-	-
9	Dissolved bone-black and muriate of potash.	73.7	18.0	41.1	—9.4
10	Nitrate of soda, dissolved bone-black and muriate of potash.	110.3	17.0	80.4	—8.5
11	Plaster,	24.7	16 0	—2.5	—7.6
12	Nothing,	24.5	21.7	-	-

Potatoes. — North Acre Soil Test (Limed), 1902.

Plots.	Fertilizers used.	Yield per Acre (Bushels).		Gain or Loss per Acre compared with Nothing Plots (Bushels).	
		Merchantable.	Small.	Merchantable.	Small.
1	Nothing,	21.3	27.7	-	-
2	Nitrate of soda,	27.3	20.3	5.5	—5.3
3	Dissolved bone-black,	26.0	22.0	2.2	—1.4
4	Nothing,	22.7	21.3	-	-
5	Muriate of potash,	69.0	12.7	43.8	—8.6
6	Nitrate of soda and dissolved bone-black.	71.3	29.0	43.6	7.7
7	Nitrate of soda and muriate of potash.	58.3	17.3	28.1	—4.0
8	Nothing,	32.7	21.3	-	-
9	Dissolved bone-black and muriate of potash.	93.7	20.0	61.6	—.3
10	Nitrate of soda, dissolved bone-black and muriate of potash.	115.3	17.3	83.8	2.0
11	Plaster,	24.3	13.7	—6.6	—4.6
12	Nothing,	30.3	17.3	-	-

Potatoes (Bushels per Acre).	Results of the Addition of Nitrogen to—				
	Nothing.	Phosphoric Acid.	Potash.	Phosphoric Acid and Potash.	Average Results.
Unlimed:—					
Merchantable, . .	1.1	26.8	—8.7	39.3	14.6
Small, ...	—2.9	5.8	7.4	.9	2.8
Limed:—					
Merchantable, . .	5.5	39.8	—15.7	22.2	13.0
Small, ...	—5.3	9.1	4.6	2.3	2.7

Value of increase, unlimed, ...	$9 32
Financial result, unlimed (gain), ...	2 92
Value of increase, limed, ...	8 34
Financial result, limed (gain), ...	1 94

Potatoes (Bushels per Acre).	Results of the Addition of Phosphoric Acid to—				
	Nothing.	Nitrogen.	Potash.	Nitrogen and Potash.	Average Results.
Unlimed:—					
Merchantable, . .	9.2	34.9	15.4	63.4	30.7
Small, ...	—3.1	5.6	—.3	—6.8	—1.2
Limed:—					
Merchantable, . .	3.8	38.1	17.8	55.7	28.9
Small, ...	—1.4	13.0	8.3	6.0	6.5

Value of increase, unlimed, ...	$18 18
Financial result, unlimed (gain), ...	11 78
Value of increase, limed, ...	18 64
Financial result, limed (gain), ...	12 24

Potatoes (Bushels per Acre).	Results of the Addition of Potash to—				
	Nothing.	Nitrogen.	Phosphoric Acid.	Nitrogen and Phosphoric Acid.	Average Results.
Unlimed:—					
Merchantable, . .	25.7	15.9	31.9	44.4	29.5
Small, ...	—9.1	1.2	—6.3	—11.2	—6.4
Limed:—					
Merchantable, . .	43.8	22.6	57.8	40.2	41.1
Small, ...	—8.6	1.3	1.1	—5.7	—3.0

Value of increase, unlimed, ...	$16 42
Financial result, unlimed (gain), ...	10 02
Value of increase, limed, ...	24 06
Financial result, limed (gain), ...	17 66

Potatoes (Bushels per Acre).	Results of the Addition to Nothing of —	
	Complete Fertilizer.	Plaster.
Unlimed: —		
Merchantable,	80.4	—2.5
Small,	—8.5	—7.6
Limed: —		
Merchantable,	83.8	—6.6
Small,	2.0	—4.6
Value of increase, unlimed,	$46.64	-
Value of decrease, unlimed,	-	$3.02
Financial result, unlimed,	27.44 gain	6.62 loss
Value of increase, limed,	50.68	-
Value of decrease, limed,	-	4.88
Financial result, limed,	31.48 gain	8.48 loss

It will be noticed that no plot in the field has produced what is regarded as a good crop. This field has now been tilled for several years without the introduction of a grass crop, and the stock of humus in the soil must be exceedingly small. It is believed that this deficiency in humus, on the presence of which, in moderate quantity, potatoes are known to be quite dependent, accounts in a measure for the relatively low yield on the plot to which a complete fertilizer was applied. It will be noticed, further, that there is not a very wide difference between the yields of the unlimed and limed portions of the several plots. With onions as a crop the difference is very large on all plots to which muriate of potash, nitrate of soda, or both of these fertilizers without dissolved bone-black are applied. The fact that potatoes show a far smaller difference may be due to either of two causes: first, that this crop is less sensitive to a deficiency of lime than onions; or, second, that the effects of the lime applied in 1898 are now largely exhausted. We have some evidence that this effect is so exhausted. The soil on the limed portion of the plots manured with muriate of potash or nitrate of soda, as shown by chemical tests, appears to be once more acid.

The Effect of the Nitrogen. — It will be remembered that nitrate of soda was applied to the four plots receiving this fertilizer in double the usual quantities, viz., at the rate of 320 pounds per acre. It increases the crop to a considerable extent only where it is used in connection with dissolved bone-black. Used in connection with this fertilizer, it gives an increase sufficient, with potatoes at 60 cents per bushel, to much more than cover the cost. The fact that it does not give an increase when used in connection with potash (which as will be seen later was the most useful of the fertilizer elements) is strongly indicative of the fact that the soil on the plot receiving nitrate and muriate of potash is once more acid, even on the part limed in 1898. A study of the results leads to the conviction that the experiment furnishes but an imperfect test as regards the necessity of an application of nitrogen on account of the poor physical and chemical condition of the soil, due to deficiency both of humus and lime.

The Effect of the Phosphoric Acid. — The dissolved bone-black (furnishing phosphoric acid), when used in connection with either or with both of the other fertilizers, gives an increase more than sufficient to cover its cost. It gives the largest increase in connection with both of the other fertilizers, which indicates a high degree of general exhaustion. It gives the smallest increase when used in connection with muriate of potash, which is still further evidence of the probable deficiency of lime, for such deficiency is known to be most marked where muriate of potash is largely employed as a fertilizer.

The Effect of the Potash. — The increase in crop produced by the application of muriate of potash where it is used alone or with either or both of the other fertilizers is in all cases much more than sufficient to cover the cost of the fertilizer. The increase on the limed half of the plots is without exception, if small and large tubers both be included, considerably greater than on the unlimed portion of the plots; indicating that, although there may be a present deficiency in the amount of lime necessary for the best results, the effects are not yet wholly exhausted. In practically all

soil tests which have been carried out by this station, whether on this farm or on farms in other parts of the State, the potato crop has always shown a marked dependence upon a liberal supply of potash, which we may safely say, therefore, should be more prominent than it usually is in the special fertilizers made for this crop. It seems worth while to call attention here to the fact that, for the sake of uniformity in soil test-work, the potash salt here employed was the muriate. It will be remembered that it has been shown as a result of numerous experiments here that the sulfate is preferable, giving better results, as indicated both by yield and quality.

VIII. — Manure Alone v. Manure and Potash.

This experiment was begun in 1890, and is intended to illustrate the relative value in crop production of an average application of manure, as compared with a smaller application of manure in connection with a potash salt. Full accounts will be found in the preceding annual reports, and summaries in the reports for 1895 and 1900. The field is level, and the soil of apparently even quality. It is divided into four quarter-acre plots. The crop for the years 1890 to 1896 was corn; for the years 1897 and 1898, mixed grass and clover; for the years 1899 and 1900, corn; for the past two years, mixed grass and clover. The present is therefore the second year that the land has been continuously in grass. Plots 1 and 3 received an application of manure at the rate of 6 cords per acre; plots 2 and 4, manure at the rate of 4 cords per acre, and high-grade sulfate of potash at the rate of 160 pounds per acre. The annual cost of the manure as applied to plots 1 and 3 is estimated to be at the rate of $30 per acre. The annual cost of the manure and the potash salt applied to plots 2 and 4 at the same price per cord for the manure is at the rate of $23.60 per acre. The yields for the present season are shown in the table: —

Yields of Hay and Rowen (Pounds).

Plots.	Hay.	Rowen.
Plot 1, ...	955	740
Plot 2, ...	915	690
Plot 3, ...	1,010	780
Plot 4, ...	900	680

The rates of yield per acre are shown below: —

Yield of Hay and Rowen per Acre (Pounds).

Plots.	Hay.	Rowen.	Total.
Plot 1, ...	3,820	2,860	6,680
Plot 2, ...	3,660	2,760	6,420
Plot 3, ...	4,040	3,120	7,160
Plot 4, ...	3,600	2,720	6,320

Averaging the yields for plots 1 and 3, we find the total to be at the rate of 6,920 pounds per acre. A similar average for plots 2 and 4 gives a yield at the rate of 6,370 pounds per acre. The larger application of manure therefore gives a yield at the rate of 450 pounds per acre more than the smaller application of manure and the potash. The difference in cost of the two applications, as shown above, is at the rate of $6.40 per acre. The 450 pounds of hay costs, therefore, this amount standing in the field. Grass standing in the field cannot be considered to be worth in an average season more than about $7 or $8 per ton of well-made hay. Although, therefore, we have a small difference in favor of the larger application of manure in total crop, the financial outcome is clearly in favor of the combination of the lesser amount of manure and the potash salt.

We have now grown on this field under substantially the present system of manuring nine corn crops and four hay crops, and the results may be briefly stated as follows: —

1. The corn crops under the two systems of manuring have been practically equal in value.

2. The hay crops have been slightly larger on the plots receiving the more liberal application of manure alone; but these increases have been produced at a cost, where manure is estimated at $5 per cord in the field, which is greater than their value.

IX. — Special Corn Fertilizer *v.* Fertilizer Richer in Potash.

This field has been used continuously in experiments designed to throw light upon the question of the proper use of fertilizers for the corn crop since 1891. From that year to 1896 inclusive the crop was corn; in 1897 and 1898 the crop was mixed grass and clover; in 1899 and 1900, it was corn; and for the past two years, it has been grass and clover. A full account of results to date will be found in preceding annual reports. The especial object in view is to test the question as to whether the special corn fertilizers offered in our markets are of such composition as is best suited for the production of corn in rotation with mixed mowing. The field is divided into four quarter-acre plots, and throughout the entire period during which the experiment has continued two of these plots (1 and 3) have yearly received an application of mixed fertilizers, furnishing the same amounts of nitrogen, phosphoric acid and potash as would be furnished by 1,800 pounds of fertilizer of the composition of the average of the special corn fertilizers analyzed at this station. This average in 1899, since which date there has been no change in the kinds and amounts of fertilizers used, was as follows: —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The fertilizers analyzed varied widely in composition, the range for each of the elements being shown by the following: —

	Per Cent.
Nitrogen,	1.5– 3.7
Phosphoric acid,	9.0–13.0
Potash,	1.5– 9.5

The other two plots (2 and 4) have annually received an application of materials substantially the same in kind and quantity as those recommended in Bulletin No. 58 for corn on soils poor in organic matter. The essential difference between the applications on the two pairs of plots is that 2 and 4 receive materials furnishing a much larger quantity of potash and much less phosphoric acid than the other pair of plots. The fertilizers applied to the several plots are shown below: —

Fertilizers used.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	–
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Sulfate of potash,	37.5	62.5

The present is the second season that this field has now been in grass. The past season has been favorable to the hay crop, the field was cut twice, and the hay was weighed and housed in excellent condition. The tables show the yields: —

Yields of Hay and Rowen, 1902 (Pounds).

Plots.	Hay.	Rowen.	Total.
Plot 1 (lesser potash),	3,712	1,540	5,252
Plot 2 (richer in potash),	5,072	1,900	6,972
Plot 3 (lesser potash),	3,992	1,260	5,252
Plot 4 (richer in potash),	5,012	1,560	6,572

Averaging the two pairs of plots, we have the rates of yield per acre for hay, rowen and total shown below: —

Average Yield per Acre (Pounds).

Plots.	Hay.	Rowen.	Total.
Plots 1 and 3,	3,852	1,400	5,252
Plots 2 and 4,	5,042	1,730	6,772

It will be noticed that the yields both of hay and rowen were considerably heavier on plots 2 and 4 (*i.e.*, the plots which received fertilizers richer in potash) than on the other pair of plots. The proportion of clover was much the larger on plots 2 and 4; and, as clover is superior in nutritive value to grass, it is evident that the superiority of the crop was even greater than the weight difference in yield in itself indicates. The cost of the fertilizers applied to plots 1 and 3 exceeds that of the fertilizers applied to plots 2 and 4 at the rate of about $4 per acre. We have, then, as a result of this experiment for this year, 6,772 pounds of hay of superior nutritive value, produced at a cost of $4 less than the 5,252 pounds produced by the other pair of plots. This result is in exact accordance with the teachings of the soil test on the south acre. There can be no doubt that potash should be more abundant in fertilizers for corn than is usually the case. It is important to point out the further fact that the difference between the two pairs of plots, as indicated by the greater productivity of the plots receiving the heavier application of potash, seems to be increasing from year to year. The results of this experiment to date may be briefly stated as follows: —

1. The crops of corn thus far have been substantially equal under the two systems of manuring.

2. The crops of hay have always been larger on the plots where more potash has been used, and the nutritive value pound for pound has been greater on account of the larger proportion of clover.

In conclusion, I may quote from my report for last year: —

In view of the fact that the clover sod when turned is exceedingly favorable for succeeding crops, it is confidently anticipated

that the differences in yields under the two systems of manuring will increase from year to year, and that the superiority of the mixture of fertilizers containing more potash will therefore become increasingly evident.

X. — Experiment in manuring Grass Lands.

In this experiment, which has continued since 1893 upon one uniform system, our object is to test the value for production of grass of the system of using wood ashes, ground bone and muriate of potash, and manure, in rotation. Owing, however, to the fact that the land has been for many years in grass, and that it has never been cultivated consecutively for a sufficiently great length of time to free it from weeds, the sod had become considerably infested with daisies, ragged robin, buttercups, and a number of other species. It has accordingly been decided to break up and reseed a part of the land. A portion has been cultivated for two years, and is now reseeded. This portion constitutes a part of plot 3. This year, after the harvest of the first crop, which was cut early to avoid ripe weed seeds, a portion each of plots 1 and 2 was broken up. This was frequently harrowed between the date of ploughing, which was about the middle of July, and the date of seeding, which was August 15. The portion of plot 3 not previously broken up has been similarly treated. The area reported upon this year, therefore, comprises only a portion of the plots included in this field, the total area of which is about nine acres.

The rates at which the several manures are employed are as follows: wood ashes, 1 ton per acre; ground bone, 600 pounds, and muriate of potash, 200 pounds, per acre; manure, 8 tons per acre.

The plot which receives wood ashes one year is the next year manured with bone and potash, and the third year with manure.

The manuring of the several plots is so planned that each year we have one plot under each of the systems of manuring. For the last three years the plots receiving respectively wood ashes and bone and potash have also received

nitrate of soda at the rate of 150 pounds per acre. The manure is always applied in the fall; the ashes, and the bone and potash and the nitrate of soda, in early spring.

The past season has been in general favorable to the hay crop, but our yields on this field are lower than usual, chiefly, it is believed, on account of the fact that both the first and second cuttings were made earlier than usual, which, as has been stated, was for the purpose of avoiding ripe weed seeds. The yields of hay, and of rowen, where any was cut, and the totals for each system of manuring, were as follows: —

Fertilizers used.	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
On barnyard manure,	2,396	1,805	4,201
On bone and potash and nitrate of soda,	2,661	1,242	3,903
On wood ashes and nitrate of soda,	3,723	-	3,723

The average yield of the entire area for this year is 3,942 pounds; the average for the period 1893 to the beginning of the present year was 6,619 pounds; the average to date, 6,413 pounds. The plots when dressed with manure have averaged 6,655 pounds; when dressed with bone and potash, 6,420 pounds; and when dressed with wood ashes, 6,094 pounds. The average yields for this year, as will be seen, are materially below the general averages. As has been stated, this is undoubtedly accounted for chiefly by the difference in the time of cutting. The average even for this year constitutes a very satisfactory crop, and for the entire period is such as to render the hay crop, at the prices which the manures used cost, a decidedly profitable one.

XI. — Experiment in the Application of Manure.

The experiment now to be reported is in continuation of work begun in 1899. It has for its object to determine whether it is better to spread fresh manure during late fall and winter, allowing it to remain upon the surface until spring, or to put the manure when hauled out into large

heaps, to be spread just before ploughing the land in the spring. A full account of the plan of the experiment will be found in the last annual report. The field contains five plots, one-half of each having the manure spread in winter, the other half put into a large heap and spread in spring. We have, in reality, then, five parallel experiments yearly. In 1901 this field produced a crop of Japanese barnyard millet. After the millet was harvested, the field was ploughed and sown to winter rye, which served as a cover crop. During the past season the field has been in corn for the silo. The soil is naturally cold, and with the cool summer it produced but a small yield. The actual and relative yields of the several plots of rather more than one-fourth acre each are shown in the following table: —

Actual and Relative Yields of Ensilage Corn.

Plots.	Manuring Previous to 1899.	Actual Yields (Pounds).		Relative Yields (Per Cent.).	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1	Barnyard manure,	5,275	5,480	100	103.9
2	Wood ashes,	4,780	4,650	100	97.3
3	No manure,	2,600	3,900	100	150.0
4	Fine-ground bone and muriate of potash.	4,480	4,105	100	91.6
5	Fine-ground bone and sulfate of potash.	4,905	5,325	100	108.6

In previous years the south half (spring manured) of each plot has without exception given a much superior yield to the north half. This year there are two exceptions: plot 2, where the difference, however, is very small; and plot 4, where there is a difference of 375 pounds in favor of the north or winter-manured half. It must be stated, however, that, owing to unavoidable conditions, one load of the corn on the south half of plot 4 lay upon the ground as it was cut from Saturday night until Monday. There can be no doubt that there was a considerable loss of weight, due to drying. We must not, therefore, attach any special

significance to the results upon this plot. The results upon the others are practically confirmatory of the results of previous years. The differences, however, are considerably less. In 1900, the yield of the winter-manured portion of each plot being considered as 100, the yields of the spring-manured portion of the plots varied from 103 to 125. In 1901 the relative yields of the spring-manured plots, on the same basis, varied from 118 to 177. The smaller differences this year are believed to be in part at least a consequence of the fact that the conditions prevailing during the winter of 1901 and 1902 were such that there was much less washing over the surface of the plots, which, it will be remembered, slope lengthwise, than during the two preceding winters. The smaller differences may also be in part due to the unfavorable effects of the season, which prevented entirely normal development on any part of the field. It is believed that our experiments indicate decisively the necessity of greater care than is always taken to avoid spreading manures on slopes during late fall and winter. Our differences in yield this year are not, it is true, sufficiently great to pay for the extra cost of rehandling the manure, which is first piled in the field. During the two past years the differences in crops have been much more than sufficient to pay this extra cost. The experiment will be continued.

XII. — Nitrate of Soda for Rowen.

The present is the third year during which we have conducted experiments for the purpose of determining whether an application of nitrate of soda after the harvest of the first crop of hay will give a profitable increase in the rowen crop. The results for the two preceding years have with one exception on a timothy sod shown an increase more than sufficient to cover the cost of the nitrate and its application. The experiments of this year were carried out upon a timothy sod which was seeded in 1899. This mowing was top-dressed this spring as follows: —

	Pounds per Acre.
Nitrate of soda, ...	150
Fine-ground bone, ...	400
Muriate of potash, ...	200

The product at the first cutting was at the rate of 5,640 pounds of hay per acre.

Eight equal plots were laid out, and on the alternate plots nitrate of soda was applied, — to two at the rate of 150 pounds to the acre, to one at the rate of 200 pounds, and to another at the rate of 250 pounds. The first crop of timothy was cut on July 11 and 14. The nitrate was applied on July 22. The rowen was cut on September 22 and weighed on October 3, in good condition. The rates of yield per acre are shown in the following table : —

Plots.	Fertilizers used.	Pounds.
Plot 1, ...	No nitrate, ...	459
Plot 2, ...	Nitrate of soda, 150 pounds, ...	826
Plot 3, ...	No nitrate, ...	367
Plot 4, ...	Nitrate of soda, 150 pounds, ...	789
Plot 5, ...	No nitrate, ...	257
Plot 6, ...	Nitrate of soda, 200 pounds, ...	1,320
Plot 7, ...	No nitrate, ...	587
Plot 8, ...	Nitrate of soda, 250 pounds, ...	1,542

The average results were as follows : —

	Pounds.
Average no-nitrate plots, ...	417.5
Average increase due to application of 150 pounds of nitrate,	390.0
Increase due to application of 200 pounds of nitrate, . .	902.5
Increase due to application of 250 pounds of nitrate, . .	1,124.5

The moisture conditions on the different plots of this field, which is of considerable length, are not exactly uniform, being somewhat more favorable toward that end of the field on which the larger applications of nitrate of soda were made. It is believed that this difference in moisture conditions in part accounts for the better apparent effect of the nitrate where applied in the larger quantities. If we determine the increases apparently due to the nitrate by comparison of the yields on plots to which such application

was made with the nearest nothing plots only, the apparent effect is as follows: —

	Pounds.
Average increase due to application of 150 pounds of nitrate,	446.5
Increase due to application of 200 pounds of nitrate, . .	898.0
Increase due to application of 250 pounds of nitrate, . .	955.0

All these increases are more than sufficient to cover the cost of the application of nitrate made.

XIII. — Variety Test, Potatoes.

During the past year we have grown, under conditions allowing a fair opportunity for comparison, thirty-three varieties of potatoes. The seed of all varieties was the first generation of our own growing. We included for purposes of comparison an equal area of one of the standard varieties, — Beauty of Hebron, — with seed of the second generation, from northern Maine. We raise our own seed, because it is recognized that the locality in which seed stock is produced and the way in which it is stored and handled has much to do with its productive capacity. We cultivate all varieties of potatoes that we test, therefore, two years, the first year being the preliminary test, made with small quantities of seed gathered from the many different sources from which a list of varieties must be made up. It is the product of this first crop that we use a second year in a final test, the seed of all varieties being stored and handled in precisely the same way. It is the results of this second year's test which are here reported.

The seed tubers planted this year were selected to as nearly as possible an average size of 60 grams in weight for each variety. The tubers were treated with corrosive sublimate in the ordinary way on April 9, and were spread in a light and sunny room in a single layer until May 14, when they were planted, being first cut to pieces of two good eyes each. The pieces were planted 1 foot apart in rows 3 feet apart. The field is one which has been used for a number of years in experiments with corn, in growing which a moderate application of fertilizers alone has been made.

The soil is a medium loam underlaid by gravel, and with perfect natural drainage, — a good potato soil. It received this year an application of manure from milch cows at the rate of 4 cords per acre. A fertilizer mixture was made, containing: —

	Pounds.
Nitrate of soda,	80
Dried blood,	100
Dry ground fish,	180
Acid phosphate,	280
High-grade sulfate of potash,	160

This mixture was used in the drill, being scattered widely the full length of the open furrow at the rate of 1,600 pounds per acre. The crop was thoroughly cared for, and sprayed three times with a combined insecticide and fungicide. This application did not prove altogether effective, although there was no rot. Growth was normal, and no signs of blight appeared until early in August. The varieties on which it showed itself previous to August 10 were: All the Year Round, Daughter of Early Rose, Early Carmen, Early Trumbull, Early Eureka, Early Rose, Early Pioneer, Ensign Bagley, Ford 1902, Harvest King, Honoeye Rose Seedling, Northern Beauty, New England Thoroughbred, Sunlight, and Smith's Six Weeks. Those on which it showed itself later than August 20, and which therefore may fairly be considered unusually disease-resistant, were: Livingston, Million Dollar, Mark Hanna, and Smith's '99.

The table shows the dates at which the vines of the several varieties were completely dead, and the rates of yield per acre for each: —

Variety.	Vines Dead.	Merchantable (Bushels).	Small (Bushels).
All the Rear Round,	Aug. 5,	165.9	41.5
Arcadia,	Aug. 30,	235.4	12.5
Beauty of Hebron (first generation from Maine seed).	Aug. 30,	315.3	16.6
Beauty of Hebron (second generation from Maine seed).	Aug. 30,	298.7	24.9
Daughter of Early Rose,	Aug. 30,	256.2	35.3
Early Carmen,	Aug. 16,	170.0	23.9

Variety.	Vines Dead.	Merchantable (Bushels).	Small (Bushels).
Early Trumbull,	Aug. 20, .	242.7	28.0
Early Eureka,	Aug. 20, .	232.3	27.0
Early Rose,	Aug. 25, .	258.2	36.3
Early Pioneer,	Aug. 20, .	185.7	27.0
Early Nancy,	Aug. 30, .	273.8	35.3
Ensign Bagley,	Aug. 25, .	262.4	50.8
Ford 1902,	Aug. 25, .	73.5	13.0
Gem of Aroostook,	–	258.2	51.8
Harvest King,	Aug. 30, .	248.9	20.8
Hammond's Wonderful,	Aug. 5, .	224.0	22.8
Honoeye Rose Seedling,	Aug. 25, .	177.4	31.1
I. X. L.,	Aug. 30, .	298.7	53.9
Livingston,	Aug. 30, .	161.8	37.3
Million Dollar,	Aug. 30, .	265.5	9.3
Mark Hanna,	Aug. 30, .	210.5	10.4
Northern Beauty,	Aug. 30, .	245.8	47.7
New England Thoroughbred,	Aug. 30, .	232.3	60.2
Rough Rider,	Aug. 30, .	214.5	43.6
Rose of the North,	Aug. 30, .	239.5	41.5
Stevens,	Aug. 25, .	148.3	38.4
Steuben,	Aug. 30, .	297.7	35.3
Sunlight,	Aug. 25, .	224.0	49.8
Smith's Six Weeks,	Aug. 30, .	65.3	36.3
Smith's '99,	–	203.3	31.1
The June,	–	77.8	19.7
Twentieth Century,	Aug. 20, .	214.7	42.5
White Giant,	Aug. 20, .	230.3	8.3

Among these varieties it will be seen that ten give a yield at the rate of over 250 bushels of merchantable tubers per acre. These, mentioned in the order of productiveness, are as follows: Beauty of Hebron (first generation from Maine seed), 315.3 bushels; Beauty of Hebron (second generation from Maine seed), 298.7 bushels; I. X. L., 298.7 bushels; Steuben, 297.7 bushels; Early Nancy, 273.8 bushels; Million Dollar, 265.5 bushels; Ensign Bagley, 262.4 bushels; Early Rose, 258.2 bushels; Gem of Aroostook, 258.2 bushels; Daughter of Early Rose, 256.2 bushels,

Six varieties, as will be seen, gave yields at the rate of between 100 and 200 bushels per acre. These, mentioned in the order of least productiveness, are the following: Stevens, 148.3 bushels; Livingston, 161.8 bushels; All the Year Round, 165.9 bushels; Early Carmen, 170 bushels; Honoeye Rose Seedling, 177.4 bushels; Early Pioneer, 185.7 bushels. Three varieties have given yields at the rate of under 100 bushels merchantable tubers per acre, viz.: Smith's Six Weeks, 65.3 bushels; Ford, 73.5 bushels; The June, 77.8 bushels. The last three varieties would seem beyond a doubt to be very inferior in productive capacity, and probably not worth cultivation. The varieties giving yields at the rate of between 100 and 200 bushels to the acre are, with one exception, well above 150 bushels; and, although giving much below the average yield for this season, they cannot be unreservedly condemned for lack of productiveness.

It may be remembered that in every test of varieties which has been made by this department of the Hatch Experiment Station the Beauty of Hebron and the Early Rose have been included. They have always ranked high in productiveness. This year it will be noticed that the Beauty of Hebron (first generation from Maine-grown seed) stands at the head, that the second generation from Maine-grown seed is next (although equalled by one other variety), and that the Early Rose is only seventh in the list. These facts constitute a striking commentary upon the claims which are usually made for new varieties. It is firmly believed that it is much wiser that potato growers shall secure seed of standard varieties grown and stored under the best conditions, than to pay high prices for new varieties, which in so many instances when carefully tested under the fairest possible conditions are found not to equal the older sorts either in productiveness or in quality. In our experience seed grown in northern Maine has invariably been found to be superior to that of our own production, even in the first generation. The Maine seed gives the larger yield, and the crop is somewhat earlier. It usually costs somewhat

more than home-grown seed, but it is richly worth the greater price.

XIV. — Poultry Experiments.

In our experiments with poultry during the past year we have confined our attention almost exclusively to questions connected with the feeding of fowls for eggs. The principal question upon which we are striving to obtain light relates to the proper relation between the different nutrients in the ration fed; or, in other words, it is a question of the best nutritive ratio. During the past year our work has been as follows: —

1. We have compared two rations in one of which corn is prominent, in the other wheat, using beef scraps as the source of animal food, the nutritive ratios being: for the ration including corn, from 1 : 4.25 — 4.74; and in the ration in which wheat is prominent, 1 : 6.25 — 6.45.

2. We have compared two rations in which respectively corn and wheat are prominent, with milk albumin as the source of animal food. The nutritive ratio of the ration including wheat has been varied from 1 : 4 — 4.48; for the ration including corn, from 1 : 4.95 — 6.05.

3. We have compared two rations in one of which buckwheat is prominent, in the other corn, with milk albumin as the source of animal food. The nutritive ratio of both these rations has been rather wide, — from about 1 : 5.5 — 6.08.

The most important points to be noted in connection with the results are as follows: —

1. In the comparison of wheat with corn, where beef scraps are the source of animal food, the egg production has been good and nearly equal on the two rations, although the hens receiving the wheat ration have been somewhat the most productive.

2. In the comparison of wheat with corn, with milk albumin as the source of animal food, the egg production has been less satisfactory, and the hens which have received the corn ration have been the more productive.

3. In the comparison of buckwheat and corn, with milk albumin as the source of animal food, the egg yield has been rather small, with the advantage decidedly in favor of the corn.

It may be remembered that, in experiments carried out in 1899 and reported in our annual report for 1900, the comparisons between corn and wheat gave results decidedly in favor of the corn. A similar line of inquiry was continued during the years 1900 and 1901. A number of comparisons were made during these years between rations respectively rich in wheat and in corn, in connection with which in all cases beef scraps were used as the source of animal food. In the experiments of these two years, as in the experiment for this year, where beef scraps are used as the source of animal food the yields are slightly in favor of the wheat. It is not believed that we are yet in position to account for the difference in results made evident by the statements just given; but it is thought that a possible explanation is offered by the fact that in the tests comparing wheat and corn in 1899 animal meal was used as the source of animal food. The principal differences between such animal meal as we have employed and beef scraps are, that the animal meal contains the more mineral matter (undoubtedly derived from bone) and less fat than the scraps. It is the latter point especially which is believed to be significant. Corn is rich in fat; wheat is relatively poor in that constituent. With animal meal as a source of animal food, corn gave the best results. It has given the best results this year where milk albumin (which is still lower in fat than animal meal) is used as the source of animal food. And again, although this is less significant because buckwheat and corn differ from each other in marked degree in the amount of fibre they contain, we find the corn when compared with brckwheat, which is relatively low in fat, with milk albumin as the source of animal food, gives much superior results. It is fully recognized that the conditions determining the egg yield from a flock are numerous, and that the relation between the different nutrients in the rations

fed is only one, and possibly by no means the most important, of these conditions. It is, however, believed that the question of the proper combination of nutrients has its importance. It is recognized that the problems arising are difficult; but the investigations will be continued, in the full belief that the results of faithful work will prove of ultimate value.

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